January 30, 1894.

North Carolina

Agricultural Experiment Station,

Bulletin No. 97.

DIGESTION EXPERIMENTS

WITH

SOY BEAN HAY, CAT-TAIL MILLET, JOHNSON GRASS HAY, SORGHUM FODDER AND BAGASSE, PEANUT-VINE HAY, COTTON-SEED MEAL, COTTON-SEED HULLS, CRIMSON CLOVER HAY, CORN MEAL, CORN-AND-COB MEAL, AND CORN SILAGE.

Publications will be sent to any address in North Carolina upon application.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION,

INCLUDING

THE FERTILIZER CONTROL STATION

AND THE STATE WEATHER SERVICE,

UNDER THE CONTROL OF THE

BOARD OF TRUSTEES OF THE A. AND M. COLLEGE.

W. S. PRIMROSE, *Chairman*, Raleigh.

W. F. GREEN ..... Franklinton.	W. E. STEVENS ..... Clinton.
D. A. TOMPKINS ..... Charlotte.	J. H. GILMER ..... Greensboro.
H. E. FRIES ..... Salem.	J. F. PAYNE ..... Alma.
N. B. BROUGHTON ..... Raleigh.	J. R. MCLELLAND ..... Mooresville.
W. R. WILLIAMS ..... Falkland.	C. D. SMITH ..... Franklin.
J. B. COFFIELD ..... Everett's.	R. W. WHARTON ..... Washington.
W. R. CAPEHART ..... Avoca.	

STATION COUNCIL.

A. Q. HOLLADAY, *Pres. A. and M. College.* W. S. PRIMROSE, H. B. BATTLE.

OFFICERS OF THE EXPERIMENT STATION.

H. B. BATTLE, PH. D ..... Director and State Chemist.
F. E. EMERY, M. S ..... Agriculturist.
GERALD MCCARTHY, B. SC ..... Botanist and Entomologist.
W. F. MASSEY, C. E ..... Horticulturist.
C. F. VON HERRMANN (U. S. Weather Bureau) ..... Meteorologist.
B. W. KILGORE, M. S ..... Assistant Chemist.
F. B. CARPENTER, B. S ..... Assistant Chemist.
W. M. ALLEN ..... Assistant Chemist.
C. B. WILLIAMS, B. S ..... Assistant Chemist.
ALEXANDER RHODES ..... Assistant Horticulturist.
ROSCOE NUNN (U. S. Weather Bureau) ..... Assistant Meteorologist.
A. F. BOWEN ..... Secretary.

RALEIGH, N. C.

DIGESTION EXPERIMENTS

WITH

SOY BEAN HAY, CAT-TAIL MILLET, JOHNSON GRASS HAY, SORGHUM FODDER AND BAGASSE, PEANUT-VINE HAY, COTTON-SEED MEAL, COTTON-SEED HULLS, CRIMSON CLOVER HAY, CORN MEAL, CORN-AND-COB MEAL, AND CORN SILAGE.

By F. E. EMERY, Agriculturist, and B. W. KILGORE, Assistant Chemist.

The value of foods depends very largely upon their composition and digestibility; the former is ascertained by chemical analysis, the latter by actual feeding trials with animals. In this bulletin are presented the results of the past year's study of the value of the cattle foods of the State. Most of the experiments were made in connection with regular feeding experiments for the production of beef and milk, the results of which are presented in another bulletin.

The Digestibility of Foods and Digestion Experiments.

A food in passing through the alimentary canal is acted upon by the alimentary agents, saliva, gastric juice, bile, pancreatic juice, and the secretions of the small and large intestines, and partly dissolved or otherwise changed so as to be capable of absorption and assimilation. This portion of a food which is thus taken into the circulation of the system is said to be *digested and is the only part of a food of any direct value in the nourishment of the animal body.* The residue, or undigested portion, passes from the body unused and forms the solid excrement.

Since only the digestible or soluble portion of a food is of any nutritive value to the animal, it is of the utmost importance, in a rational and economical system of feeding, that we should know the portions of the nutrients, protein, fats, etc., (the total amounts being shown by analysis) that are actually digested. This is determined by feeding trials with animals and are known as *digestion experiments.* A digestion experiment requires a great deal of very careful experimental work, and in brief is carried out by feeding an animal a uniform and weighed quantity of food of known composition fo sufficient length of time to eliminate all residues of previously fed foods, then collecting the solid excrement for a number of days usually five or six, weighing and analyzing it. The solid excremen

Mr. R. E. Noble, formerly Assistant Chemist of the Station, assisted in making the analyses and in working up the results of these experiments.

contains the undigested food-residue, and the difference between this and the total food consumed gives the portion digested. The results presented in this bulletin are precisely this answer obtained by animals from a number of ordinary foods and rations. Thus two foods of the same or different composition would be valued according to the amounts of digestible nutrients each contained. It is hoped that this and past bulletins of the Station on this subject will be of material benefit to the farmers of the State in giving them a better knowledge of the foods they have to deal with.

Terms Defined.

By chemical analysis, foods are separated into six classes of substances, viz:

1. *Water*, which is present in all feeding stuffs. It composes about 80 per cent. of green and succulent fodders, about 90 per cent. of root crops, 75 per cent. of silage, and 10 to 15 per cent. of hays and grains. In these it is present as mechanically adhering or hygroscopic moisture. It is a necessary constituent of the animal body, of which it makes up 40 to 65 per cent. Water is determined by heating the substance for several hours at the temperature of boiling water, at which temperature it passes off as steam.

2. *Ash* is the inorganic, or mineral matter, of plants, and is the residue left after burning till all volatile material is driven off. It is composed mainly of soda, potash, lime, and magnesia, in the form of phosphates, sulphates, chlorides, and carbonates. Ash furnishes the materials for the bony structure of animals, and enters to a much less extent into the tissues and organs.

3. *Fats* (*Ether extract*) represents whatever is dissolved from foods by dry ether. It is composed mainly of fats and oils, but contains, in addition, quantities of gums, wax and coloring matter, depending upon the substances extracted.

4. *Protein*, the term as used in connection with fodder analyses, includes *Albuminoids* and *Amides*, the albuminoids being the more valuable, and, at the same time, composing by far the larger portion of the protein compounds. They are the nitrogenous compounds of plants and animals, and are determined by estimating the nitrogen in them, which element composes about 16 per cent. of the weight of protein substances. None of the other classes of substances contain nitrogen. They are represented in the animal body by ligaments, lean meat, muscles, tendons, and tissues.

5. *Crude fiber*, or *cellulose*, is the cell wall and structure material of plants, and is usually the most indigestible portion of them, but when digested is considered of equal value to starch and sugar. The lint of cotton is almost pure cellulose. Its composition is similar to that of starch. It is determined by boiling the food-stuff with weak acid and alkali, thus dissolving all other constituents. *Crude fiber* and *nitrogen-free extract* taken together are known as *carbohydrates*.

6. *Nitrogen-free extract* is the term applied to those non-nitrogenous constituents of foods which are represented in the main by sugars, starch, dextrin, and gums. They all contain carbon, hydrogen, and oxygen, but no nitrogen, as does protein. Nitrogen-free extract is estimated by difference, it being equal to the difference between the sum of the above five constituents, water, ash, protein, fats, and crude fiber, and 100.

Dry matter represents all the substances in foods except water, and is what is left after the water is driven off or subtracted.

Coefficients of digestibility are the per cents. of the different nutrients digested, and are obtained by dividing the total amount of each nutrient consumed by the animal into the amount digested.

The nutritive ratio of a food is the ratio of the digestible protein to the sum of digestible carbohydrates and fats, the fats being previously multiplied by 2.5.*

Nutrients.—Protein, fats, carbohydrates, nitrogen-free extract and crude fiber, and mineral matter are called nutrients, because of their functions in animal nutrition. Nigrogen-free extract and crude fiber are included together under the one name of carbohydrates, because they are all compounds of carbon, hydrogen, and oxygen, and the digestible portion of each is considered of equal value and perform the same offices in animal nutrition.

Functions of nutrients.—Having defined the classes of nutrients as they occur in foods, it is now in order to state the offices performed by them in animal nutrition.

Water is not a nutrient in the sense in which the term is here used, though the animal body cannot be supported without it.

The ash, or mineral matter, furnishes the material for the bony structure of the body, and, to a far less extent, of the soft tissues. Most of our foods and rations contain an abundant supply of the mineral elements, so little or no notice need be taken of them in feeding.

Protein differs from all the other nutrients in containing the element nitrogen, and is the producer of flesh, ligaments, muscles, tendons, sinews, hair, hide, and all portions of the animal machine which has strength, except the bones. The protein bodies are of the utmost importance in the animal structure. They compose the larger part of the animal machinery, and are the exclusive source of its repair as occasioned by the continuous wear and tear of the system, due to the internal and external movements of the body; they are the basis of blood, and the source of casein in milk; and in the absence of sufficient quantities of fats and carbohydrates in the food for the production of heat and energy, they are transformed

*Experimenters and feeders now generally use factors varying from 2.2 to 2.27 for bringing fats to the same nutritive basis as carbodydrates, and we agree with them that these factors are more nearly correct than 2 5, but we adhere to the latter in order that our ratios may be comparable with those in the German standard.

into fats, and perform the office of fats in nutrition. This latter transformation may also result from an excess of protein. The heat-producing power of protein is but little different from that of carbohydrates; the amount of fat it produces is probably much less, while, as a heat-producer, fat is worth about 2.25 times as much as protein. These facts, combined with the high cost of protein in foods, renders it usually uneconomical to feed protein for the production of fat to be either stored in the body as such, or to be used as fuel, since the fats and carbohydrates perform these offices, and cost much less. It is to remembered that the protein bodies are the "flesh formers," and though they can perform the offices of fats and carbohydrates in nutrition, fats and carbohydrates cannot take the place of protein.

Fats and carbohydrates perform the same offices in the body—those of the production of heat to keep the body warm, and the force by which the animal mechanism is run. They are the "heat and force producers," and are consumed in the body as fuel, giving out heat, muscular, and intellectual energy. For the production of heat and energy one pound of fat is worth about 2.25 times as much as a pound of carbohydrates. Fats give out about 2.25 times the heat that carbohydrates do. Besides serving as heat and force producers, carbohydrates are converted in the animal body into fats, and, together with the fats of the food, are stored as such in fatty tissue. The value of carbohydrates for the production of fats is supposed to be in about the same proportion as the heat-producing powers of carbohydrates to fats.

The main and distinctive offices of the nutrients of foods are: Ash, or mineral constituents, are bone-producers; the protein bodies are the flesh-formers; and fats and carbohydrates are the heat and force producers. The nutrients already located in the animal body perform the same offices as the corresponding ones of foods.

Different Rations Experimented With.

In Technical Bulletins Nos. 3 and 4 (Bulletins 80c and 87d) were presented the results of the previous two years' work on determining the digestibility and value of certain feeding stuffs. The present bulletin contains the results of the past and third season's investigations in the same line, and includes digestion experiments and deductions therefrom, upon:

1. Soy (soja) bean hay, with two animals.
2. Cat-tail millet, with one animal (in duplicate).
3. Johnson grass hay, with one animal.
4. Sorghum fodder (pulled leaves alone), with two animals.
5. Peanut-vine hay, with two animals.
6. Sorghum bagasse, with one animal.
7. Sorghum bagasse and cotton-seed meal (ratio 1.86 to 1 eaten), with one animal.
8. Crimson clover hay (one-year old), with two animals.

9. Crimson clover hay and cotton-seed meal (ratios 6.4 to 1 and 3.09 to 1 eaten), with two animals.

10. Crimson clover hay and cotton-seed meal (ratios 3.5 to 1 and 3.53 to 1 eaten), with one animal (in duplicate).

11. Cotton-seed hulls and cotton-seed meal (ratios 3 to 1 and 2.8 to 1), two animals.

12. Cotton-seed hulls and cotton-seed meal (ratios 2.4 to 1, 2.02 to 1, and 2 to 1, eaten), with two animals, three experiments.

13. Digestibility of corn silage alone and in ration with cotton-seed meal.

14. Corn meal, with one animal.

15. Corn meal and crimson clover hay (1 to 1.83 and 1 to 2.36 eaten), with two animals.

16. Corn-and-cob meal, with one animal.

17. Crimson clover hay and corn-and cob meal (ratios 1 to 1.8 and 1 to 1.35 eaten), with two animals.

18. Composition of foods used in the experiments (see page 93).

19. Summary of coefficients of digestibility (see page 94).

The Animals Employed.

The same two goats used for the digestion work last reported* have been used during this winter's feeding. The spotted grade Jersey heifer (called "Spot"), now a promising young cow, has also been used with the goats, together with a native heifer ("Miss Haley") of about the same age for the digestion of crimson clover hay alone and rations with it. "Spot," the grade Jersey, was also fed in the digestion of sorghum fodder and soy bean hay. These heifers brought their first calves in September and October, previous to beginning the digestions in January, 1893. For a continuance of the digestion of rations of cotton-seed hulls and meal, a pair of large old steers was purchased. These when fat were turned off to the butcher, when the work was completed.

Summary of Results.

1. *Soy (soja) bean hay.*—Last year the digestibility of soy bean silage was reported. To complete our study of this plant, the digestibility of the hay was made. There is very little difference in the results of the two investigations, showing both the silage and the hay to be most valuable and highly nitrogenous fodders. As the soy bean is a leguminous, or nitrogen gathering plant, it is hoped that its cultivation and use will greatly increase.

2. *Cat-tail millet.*—The composition, digestibility, and nutritive ratio of cat-tail millet show it to be of itself a good food, and indicate that it can be fed alone with profit. This, coupled with the yield, speaks well for it.

*Bulletin No. 87d, Technical Bulletin No. 4.

3. *Johnson grass hay* is a coarse carbonaceous food with a wide nutritive ratio. It yields heavily, however, and where it can be grown without being troublesome in the cultivation of clean crops, will furnish large quantities of coarse fodder to feed with such nitrogenous foods as cotton-seed meal. The sample submitted to digestion in this experiment was rather a poor one, and the coefficients are probably somewhat lower than they would be for a first-grade hay.

4. *The sorghum fodder* (leaves alone) fed in this experiment was pulled at the time the sorghum was being stripped for grinding. Its composition, digestibility, and nutritive ratio show it to be about the same in feeding value as ordinary corn blades, though the yield of sorghum fodder is much greater per acre. As to whether it will pay to harvest sorghum fodder for feed, will depend very much upon circumstances.

5. *Peanut-vine hay* consists of the top of the plant after the kernels are removed, and resembles corn leaves in composition and digestibility, though is a somewhat more valuable food on account of the larger amount of digestible protein and narrower nutritive ratio. It could be fed alone with fair profit for slow gains. The peanut plant is a nitrogen gatherer and the tops are a good hay.

6. *Sorghum bagasse* is the residue of the stripped sorghum canes after grinding. The sample submitted to digestion was cut into short lengths with a silage cutter. It resembles cotton-seed hulls in composition; is materially more digestible than hulls, but not so readily eaten. When fed fresh, before it dries out, or is preserved in a silo, it is eaten with considerable relish. Our experience with it leads us to believe that it is a waste by-product that can be used to advantage by some.

7. *Ration of sorghum bagasse and cotton seed meal, 1.86 to 1.*—To further test the value of sorghum bagasse, it was fed in ration with cotton-seed meal in proportion of 4 to 1, but eaten in the proportion of 1.86 to 1. This ration was eaten well and was digested considerably better than a similar one of cotton-seed hulls and meal having practically the same nutritive ratio. This result, combined with that of the previous experiment on bagasse alone, indicate sorghum bagasse to be a better coarse food than cotton-seed hulls, and we considered it should be saved and utilized where a very coarse fodder can be used to advantage.

8. *One-year-old crimson clover hay.*—The digestibility of a portion of this same lot of hay was determined when new and reported last year. Its digestibility was re-determined a year later to see if it had changed in composition and digestibility and to be used in other experiments. The old hay had suffered a loss of 1 per cent. in nitrogen compounds and slight changes in other constituents, but there was very little difference in the digestibility of the two hays beyond a small decrease in the digestibility of the fats and nitrogen-free extract of the old hay.

9–10. *Rations of crimson clover hay and cotton-seed meal.*—The diges-

tibility of four rations of crimson clover hay and cotton-seed meal were determined, viz.: 6.4 to 1, 3.53 to 1, 3.5 to 1, and 3.09 to 1. They were all digested well and make good showings for the rations, but they are too heavy for ordinary feeding. Their digestibility were determined to arrive at the digestibility of cotton-seed meal, which could not be fed alone, and the results obtained for this latter material confirm our high opinion of it as being our most valuable concentrated food.

11. *Rations of cotton-seed hulls and meal, 3 to 1 and 2 8 to 1.*—These rations contain quite a large proportion of cotton-seed meal in comparison with what has usually been fed. The nutritive ratios of the rations as digested show them however to be about the same in the proportion of food constituents actually digested as are required by the German standard for fattening. These rations were well eaten and gave good results in fattening steers in our stables.

12. *Rations of cotton-seed hulls and meal, 2 to 1.*—This ration is still more concentrated and narrow in nutritive ratio than either of the preceding. In fact, the nutritive ratio of this ration is narrower than is called for by the German standard for any of the periods of fattening, yet it was readily eaten and gave good results in our feeding trials for beef.

13. *Digestibility of corn silage alone and in rations with cotton-seed meal.*—The digestibility of corn silage was determined by feeding alone and then in rations of 12 to 1, and 8 to 1 with cotton-seed meal. When fed alone 53.2 per cent. of the silage was digested; with cotton-seed meal, 12 to 1, 60.1 per cent.; with cotton-seed meal, 8 to 1, 67.4 per cent. of the silage was digested. These figures indicate that the silage was more digestible in the rations with meal than alone. The nutritive ratios of the rations of 12 and 8 pounds corn silage to 1 pound cotton-seed meal were 1 to 6.29, and 1 to 4.98, and would be good rations for the 1st and 2d periods respectively of fattening.

14. *Corn meal* is a highly digestible food, but the proportion of the food constituents in it alone are not the best for economical results in most kinds of feeding.

15. *Rations of crimson clover hay and corn meal, 2.36 to 1 and 1.83 to 1.*—These rations have a very high rate of digestibility and the proportion of nutrients in them are good, far better than in corn meal alone, and would be good rations for milk, for first period of fattening of steers, or for horses or oxen at work.

16. *Corn-and-cob meal* does not have so high coefficients of digestibility as corn meal but the proportion of food constituents in the two are not very different, and the remarks about corn meal apply also to corn-and-cob meal. According to our experiments and calculations 12.96 per cent. of the total digestible dry matter in ear corn was saved by feeding the ground cobs with the meal.

17. *Rations of crimson clover hay and corn-and-cob meal, 1.8 to 1, and 1.35 to 1.*—These rations have quite a high rate of digestibility, and

the proportion of the food constituents in the ration of 1.8 pounds hay to 1 pound corn-and-cob meal are such as to recommend the ration for the same purposes as given for the rations of crimson clover hay and corn meal in paragraph 15. The nutritive ratio of the ration of 1.35 pounds hay to 1 pound meal is rather wide for most feeding purposes.

18. *Composition of foods and coefficients of digestibility.*—To facilitate examination and comparison the composition of all the foods used in the experiments and a summary of the coefficients of digestibility of all the foods and rations with nutritive ratios are brought together in tables A and B, (pages 95 and 96). The composition of the foods is shown on basis of air-dry material as they are fed and is the basis to be used in calculating rations from like foods on hand. In addition to the composition of the foods obtained by analysis, is presented, also, the percentage of digestible nutrients in each, calculated from the percentage composition of the foods in the table by multiplying by the coefficients of digestibility of each food and nutrient. These per cents. represent so many pounds of digestible nutrients in 100 pounds of the air-dry hay or food, and are in convenient shape to be used in making rations from these foods.

TABLE A.—Showing Composition of Foods Used in Experiments.

Foods.	Parts in 100 of air-dry substance							Per cent. of digestible matter					
	Water.	Dry matter.	Ash.	Protein.	Fats. (Ether extract)	N-free extract.	Crude fiber.	Dry matter.	Ash.	Protein.	Fats.	N-free extract.	Crude fiber.
Soy (soja) bean hay	17.38	82.62	6.35	15.53	2.66	32.52	25.55	51.52	1.50	11.04	.78	22.38	15.54
Cat-tail millet	11.04	88.96	8.10	11.56	2.28	40.20	26.82	55.42	5.54	7.23	1.05	23.77	17.84
Johnson grass hay	12.31	87.69	5.15	5.77	1.67	44.80	30.30	47.81	2.89	2.58	.66	24.36	17.52
Sorghum fodder (leaves alone)	12.43	87.57	4.56	9.60	4.55	44.93	23.93	55.25	1.34	5.84	2.12	28.99	16.84
Peanut-vine hay	10.44	89.56	6.80	10.31	3.57	42.92	25.96	53.60	1.39	6.53	2.35	29.83	13.47
Sorghum bagasse	11.25	88.75	2.88	3.44	1.44	50.47	30.52	53.78	.38	.47	.67	32.72	19.46
Cotton-seed meal	7.03	92.97	5.76	39.35	11.84	29.54	6.48	68.15	1.81	34.55	10.62	18.17	3.01
Crimson clover hay	11.46	88.54	6.27	15.04	2.01	38.49	26.73	54.11	3.73	10.26	.87	25.62	13.74
Cotton-seed hulls	12.35	87.65	1.65	4.22	2.74	35.56	43.48	36.02	.35	.25	2.18	12.20	20.61
Corn meal	12.68	87.32	1.32	8.81	4.39	71.25	1.55	75.87	.....	5.89	3.53	63.13	.....
Corn-and-cob meal	12.43	87.57	1.24	7.90	3.33	67.10	8.00	68.94	.....	5.15	2.82	57.44	3.82
Cow pea vine hay*	11.90	88.10	8.42	14.43	2.49	41.22	21.54	52.15	3.79	9.31	1.24	29.14	9.24
Lucerne, or alfalfa hay*	11.53	88.47	6.90	14.89	2.24	34.18	30.26	52.55	.....	10.85	1.15	23.21	13.95
Red clover hay*	11.63	88.37	6.15	12.50	2.43	40.43	26.81	45.69	.....	6.17	1.03	23.28	12.73
Corn fodder, whole plant*	32.19	67.81	4.32	4.81	1.28	37.15	20.21	.....	.....	2.60	.90	23.63	13.84
Timothy hay*	10.21	89.79	4.22	6.18	2.19	46.91	30.29	51.90	1.46	3.03	1.21	30.16	16.14
Red top hay*	9.52	90.48	5.93	7.70	2.14	46.19	28.52	52.12	1.44	4.65	.94	27.30	17.45
Orchard grass hay*	9.80	90.20	5.63	6.82	2.38	42.12	33.23	51.68	1.95	4.08	1.29	23.42	20.40
Mixed hays*	15.41	84.59	4.73	6.25	2.09	40.30	31.21	45.93	.....	2.99	1.04	22.93	14.95

*These are inserted for comparison with the materials experimented upon, and are each the average results obtained upon quite a number of samples.

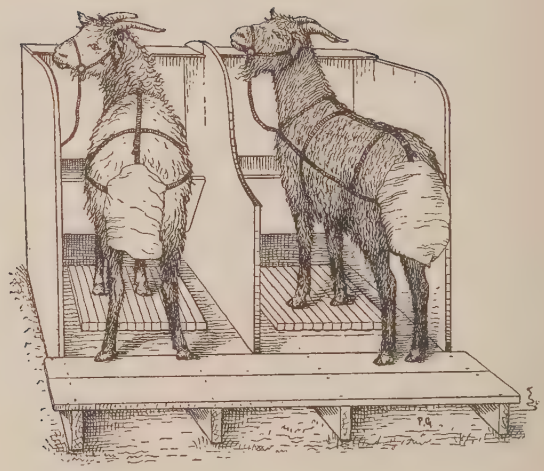
TABLE B.—Summary of Coefficients of Digestibility and Nutritive Ratios.

Foods.	No. determinations.	Dry matter.	Ash.	Protein.	Albuminoids.	Fats. (Ether extract)	Nitrogen-free extract.	Crude fiber.	Nutritive ratio, 1:
Soy (soja) bean hay	2	62.26	28.70	71.08	54.18	29.22	68.81	60.84	8.55
Cat-tail millet	2	62.36	08.42	62.17	41.49	26.10	59.11	59.51	9.17
Sorghum fodder leaves alone	2	66.09	29.47	60.81	45.14	48.66	64.56	70.38	8.94
Johnson grass hay	1	54.76	36.10	44.71	30.58	39.48	54.87	57.88	14.22
Peanut vine hay	2	59.85	21.44	68.81	52.85	65.94	69.56	51.90	7.09
Sorghum bagasse	1	60.60	18.35	18.65	2.79	46.42	64.84	68.75	120.8
Ration sorghum bagasse and cotton-seed meal, 1.86 to 1	1	62.18	7.10	77.77	77.27	84.54	62.54	54.14	4.19
Crimson clover hay (one-year old)	2	60.11	59.42	68.28	61.14	43.28	66.55	51.40	4.47
Ration crimson clover hay and cotton seed meal, 6.4 to 1	1	61.90	54.31	74.17	69.77	67.98	64.13	52.24	3.23
Ration crimson clover hay and cotton-seed meal, 3.5 to 1	2	60.41	54.08	74.77	71.62	71.15	66.36	42.35	2.8.
Ration crimson clover hay and cotton seed meal, 3.09 to 1	1	66.91	54.28	81.81	78.94	75.43	67.45	55.09	2.68
Cotton-seed meal in above rations	4	78.3	31.5	87.8	87.1	88.7	61.5	46.4	1.38
Ration cotton-seed hulls and meal, 3 to 1	1	54.95	28.87	60.98	60.50	86.96	55.87	49.63	5.89
Ration cotton-seed hulls and meal, 2.8 to 1	1	51.54	33.01	62.33	61.82	84.20	51.76	48.55	5.79
Ration cotton-seed hulls and meal, 2.4 to 1	1	52.04	30.27	61.55	61.09	83.68	53.35	48.12	4.88
Ration cotton-seed hulls and meal, 2 to 1	2	58.55	26.84	64.67	64.19	82.26	49.47	49.58	4.37
Corn meal	1	86.89	....	66.89	66.89	89.47	94.22	....	14.92
Ration corn meal and crimson clover hay, 1 to 2.36	1	68.69	41.81	62.38	56.32	68.21	81.26	47.17	6.77
Ration corn meal and crimson clover hay, 1 to 1.83	1	73.60	62.11	70.57	65.73	72.41	83.84	50.93	6.64
Corn-and-cob meal	1	78.78	....	65.21	65.21	84.59	85.61	47.69	13.29
Ration corn-and-cob meal and crimson clover hay, 1 to 1.8	1	65.71	44.72	63.67	59.67	62.17	76.81	44.95	6.58
Ration corn-and-cob meal and crimson clover hay, 1 to 1.35	1	70.37	49.13	59.33	55.39	66.92	80.34	56.81	10.04

TABLE OF CONTENTS.

(PAGES 101 TO 132.)

[The previous pages present a condensed Summary of the several subjects treated in this Bulletin. The detailed account will be found in the following pages (101 to 132). Persons who do not receive these latter pages can be supplied by making application to Dr. H. B. BATTLE, Director, Raleigh, N. C.]



I. DIGESTION OF SOY (SOJA) BEAN HAY,

BY BLACK GOAT, AND GRADE JERSEY COW, "SPOT."

Date of experiment, February and March, 1893.

Daily ration { Black goat, 1200 grams fed.
Spot, 16 pounds.

Total period, 14 days.

Collection period, the last 5 days.

Analytical and other data for obtaining coefficients of digestibility are contained in Tables I and II.

FEEDS.—Previous to the beginning of each experiment, the feeding material or materials were thoroughly mixed in sufficient quantity for the entire experiment, and from this mixture the separate feeds for the whole period were weighed out, thus obviating any error from change of moisture. Samples for analysis were also taken from the above mixture.

WASTE.—The total wastes were in all cases saved and sampled for analysis at the end of the experiment.

The soy beans for this experiment were grown after an early crop and were cut in September, when a portion was in bloom, with the most forward part of the crop showing nearly mature seed. One thousand pounds were cut, and stored in the barn loft to cure. This dried to two hundred and seventy-five pounds of hay, losing about 73 per cent. of the green weight.

Neither the cow nor the goat ate enough of this hay to maintain the live weight. The digestion by the two animals was quite uniform. Comparing the coefficients found for this hay with those for soy bean silage, there is a fair degree of correspondence. The dry matter and nitrogenenous compounds gave a rather higher per cent. in the hay, while the nitrogen-free extract and crude fiber of the hay were considerably better digested than were those of the silage. These differences were not wider than those occurring between the coefficients for the same constituents when the animals were fed on silage or hay.

TABLE I.—Showing percentage Composition of Soy Bean Hay, Waste, and Solid Excrement.

	Water.	DRY MATTER CONTAINS						
		Dry matter.	Ash.	Protein (N×6 25)	Albumi'ds (Alb, N ×6.25)	Fats (Ether extract)	N-free extract.	Crude fiber.
Soy bean hay	17.38	82.62	7 69	18.80	11.81	3.22	39.36	30 93
Waste, soy bean hay, black goat	11.84	88.16	20.70	18.65	11.37	3.65	30.20	26.80
Waste, soy bean hay, grade Jersey cow, "Spot"	14.89	85.11	7.43	18 56	11.94	1.62	50.82	21.57
Solid excrement, black goat	52 59	47.41	14.04	14.83	14 83	6.52	32.22	32.39
Solid excrement, grade Jersey cow, "Spot"	80.31	19.69	10.92	14.11	14 11	5.66	33.96	35.35

TABLE II.—Showing Nutrients Consumed and Excreted in Ounces†, with percentages Digested.

BLACK GOAT.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds. (Alb, N ×6.25)	Fats. (Ether extract.)	N-free extract..	Crude fiber.
Soy bean hay fed	211.64	174.86	13.45	32.87	20.65	5.63	68.82	54.08
Waste, soy bean hay	55.64	49.05	10.15	9.15	5.58	1.79	14.81	13.14
Total consumed	156.00	125 81	3.30	23.72	15.07	3.84	54.61	40.94
Total solid excrement	100.91	47.84	6.72	7.09	7.09	3.12	15.41	15.50
Total digested	.....	77.97	.....	16.62	7.98	.72	38.60	25.44
Per cent. digested	.....	61.97	.....	70.07	52.95	18.75	71.47	62.14

GRADE JERSEY COW, "SPOT."

Soy bean hay fed	1280.0	1057.5	81.32	198.81	124.89	34.05	416.23	327.08
Waste, soy bean hay	183.3	156.0	11.59	28.95	18.63	2.58	79.27	33.65
Total consumed	1096.7	901.5	69.73	169.86	106.26	31.52	336.96	293.43
Total solid excrement	1705.3	335.8	36.67	47.38	47.38	19.01	114.04	118.71
Total digested	.....	565.7	33.06	122.48	58.88	12.51	222.92	174.72
Per cent. digested	.....	62.75	47.41	72.10	55.41	39.69	66.15	59.54
Mean of both animals	.....	62.36	23.70	71.08	54.18	29.22	68.81	60.84
*Mean coefficients for soy bean silage	.....	59.02	56.71	75.75	66.1	71.86	52.02	54.80

Mean nutritive ratio of soy bean hay 1:3.55.

*Mean nutritive ratio of soy bean silage 1:4.22.

*Bulletin 87d, Technical Bulletin No. 4, p. 14, N. C. Experiment Station.

†One ounce is equivalent to 28.35 grams.

II. DIGESTION OF CAT-TAIL MILLET,

BY GRAY GOAT.

Date of experiment, January and February, 1893.

Daily ration { First experiment, 900 grams. Second experiment, 900 grams.

Total period, 23 days.

Collection period, the last 12 days, divided into two periods of 5 and 7 days each.

Analytical and other data for obtaining the coefficients of digestibility are presented in Tables III and IV.

TABLE III.—Showing percentage Composition of Cat-tail Millet, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Cat-tail millet	11.04	88.96	9.10	12.99	8.25	2.56	45.20	30.15
Waste, cat-tail millet, 1st experiment	12.14	87.86	7.02	14 09	8.31	2.47	43.89	32.53
Waste, cat-tail millet, 2d experiment	18 53	81 47	7.02	12 50	8.37	2.55	44.81	33 12
Solid excrement, 1st experiment	53.01	46 99	8.20	12.29	12.29	3.93	50.06	25.52
Solid excrement, 2d experiment	56.21	43.79	7 88	13.23	13.23	3.45	48.50	26.94

TABLE IV.—Showing Nutrients Consumed and Excreted in Grams with percentages Digested.

GRAY GOAT, FIRST EXPERIMENT.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6 25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Cat-tail millet fed	4500.0	4003.2	364.29	520.02	330.26	102.48	1809.45	1206.96
Waste, cat-tail millet	1086.0	954.2	66.98	134.45	79.29	23.57	418.80	310.40
Total consumed	3414.0	3049.0	297.31	385.57	250.97	78.91	1390.65	896.56
Total solid excrement	2365.0	1111.3	91.13	136.58	136.58	43.67	556.32	283.60
Total digested		1937.7	206.18	248.99	114.39	35.24	834.33	612.96
Per cent. digested		63.55	69.35	64.58	45.58	44.66	60.00	68.36

GRAY GOAT, SECOND EXPERIMENT.

Cat-tail millet fed	6300.0	5604.5	510.01	728.02	462.37	143.48	2533.23	1689.76
Waste, cat-tail millet	937.5	763.8	53.62	95.48	63.93	19.48	342.26	252.97
Total consumed	5362.5	4840.7	456.39	632.54	398.44	124.00	2190.97	1436.79
Total solid excrement	4304.4	1884.9	148.53	249.37	249.37	65.03	914.18	507.79
Total digested		2955.8	307.86	383.17	149.07	58.97	1276.79	929.00
Per cent. digested		61.06	67.45	60.57	37.41	47.55	58.27	64.66
Mean of two experiments		62.30	68.40	62.57	41.49	46.10	59.13	66.51

Mean nutritive ratio of cat-tail millet 1:6.15.

Cat-tail millet (*Pennisetum spicatum*) is also known as Pearl and Egyptian millet. It was sown after a second crop of red clover had been cut on land which has been raised to a good state of cultivation by use of stable manure on forage crops. The millet was cut from heading out to past bloom as needed to feed, and yielded at the rate of 16,745 pounds per acre. That cut for this experiment was the first when the panicles were just appearing above the leaves. It was cured under cover and was in good condition when used.

The coefficients of digestibility and the nutritive ratio point this out as of great value to feeders of stock who need a good heavy crop of coarse fodder. It is a gross feeder, and stable manure should be applied freely for profitable returns.

III. DIGESTION OF JOHNSON GRASS HAY,

BY BLACK GOAT.

Date of experiment, January and February, 1893.
Daily ration, 3 pounds.
Total period, 14 days.
Collection period, the last 5 days.

TABLE V.—Showing percentage Composition of Johnson Grass Hay, Waste, and Solid Excrement.

			DRY MATTER CONTAINS					
	Water.	Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Johnson grass hay	12.31	87.69	5.87	6.58	6.13	1.90	51.10	34 55
Waste, Johnson grass hay	11.73	88.27	4.58	4.14	4.14	1.34	49.12	40.82
Solid excrement	52.25	47.75	6 22	9.32	9.32	2.86	52.15	29.45

TABLE VI.—Showing Nutrients Consumed and Excreted in Grams with percentages Digested.

BLACK GOAT.

			DRY MATTER CONTAINS					
	Total amount.	Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Johnson grass hay fed	6804.8	5967.1	350.27	392.64	365.78	113.37	3049.19	2061.63
Waste, Johnson grass hay	2082.0	1837.8	84.17	76.08	76.08	24.63	902.73	750.19
Total consumed	4722.8	4129.3	266.10	316.56	289.70	88.74	2146.46	1311.44
Total solid excrement	3932.5	1877.8	116.80	175.01	175.01	53.70	979.27	553.01
Total digested		2251.5	149.30	141.55	114.69	35.04	1167.19	758.43
Per cent. digested		54.52	56.10	44.71	39.58	39.48	54.37	57.83

Nutritive ratio of Johnson grass hay 1:14.22.

Analytical and other data for obtaining the coefficients of digestibility are presented in Tables V and VI.

The Johnson grass hay used in this experiment was grown on a neighboring farm, and was rather weather beaten, having been wet in a few days of dull weather. It was cut at the stage of panicling to bloom. This is a coarse, rank growing grass, capable of great yields from two or three cuttings in a single season, but common experience puts it under ban as a troublesome weed in cultivated grounds.

The low digestibility and wide nutritive ratio found for this sample is probably partly due to the weathering.

IV. DIGESTION OF SORGHUM FODDER,

BY BLACK GOAT AND GRADE JERSEY COW, "SPOT."

Date of experiment, February, 1893.

Daily ration { Black goat, 1200 grams. / Spot, 18 pounds.

Total period, 13 days.

Collection period, the last 5 days.

Analytical and other data for obtaining the coefficients of digestibility are contained in Tables VII and VIII.

TABLE VII.—Showing percentage Composition of Sorghum Fodder, Waste and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Sorghum fodder	12.43	87.57	5.21	10.96	7.87	5.19	51.31	27.33
Waste, sorghum fodder, black goat	17.51	82.49	8.51	11.29	8.56	4.20	50.80	25.20
Waste, sorghum fodder, grade Jersey cow, "Spot"	17.56	82.44	11.60	13.16	10.50	5.00	50 06	20.18
Solid excrement, black goat	53.80	46.20	9.66	11.02	11.02	7.05	48.04	24.23
Solid excrement, grade Jersey cow, "Spot"	85.08	14.92	8.89	12.25	12.25	8.28	50.94	19.64

The fodder used in this experiment was from varieties grown for syrup, Black African cane, which yielded 1174.5 pounds of cured fodder per acre; and Collier's, 1111.4 pounds per acre. The fodder was stripped in the usual way of pulling corn fodder when the canes were wanted for grinding. The fodder had a good effect on the animals, and though the cow fell off one and a-half pounds in yield of milk per day from the last six days of the previous period to the last six on sorghum fodder, this is not a very great decrease when comparison of rations is made. Milk was produced at very nearly

the same cost from 18 pounds daily of this fodder, as from 15⅔ pounds of hay and 4½ pounds of cotton-seed meal. The volume of milk and value of excrement was greater, however, on the hay and meal ration.

TABLE VIII.—Showing Nutrients Consumed and Excreted in Ounces with percentages Digested.

BLACK GOAT.

		DRY MATTER CONTAINS					
	Total amount.	Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Sorghum fodder fed	211.64	185.33	9.66	20.31	14.58	9.62	95.09	50.65
Waste, sorghum fodder	30.24	24.94	2.12	2.82	2.13	1.05	12.67	6.28
Total consumed	181.40	160.39	7.54	17.49	12.45	8.57	82.42	44.37
Total solid excrement	139.22	64.32	6.21	7.09	7.09	4.53	30.90	15.58
Total digested		96.07	1.33	10.40	5.36	4.04	51.52	28.79
Per cent. digested		59.89	17.64	59.46	43.05	47.14	62.51	64.88
GRADE JERSEY COW, "SPOT."								
Sorghum fodder fed	1440.0	1261.0	65.70	138.21	99.24	65.45	647.02	344.63
Waste, sorghum fodder	24.6	20.3	2.35	2.67	2.13	1.02	10.16	4.10
Total consumed	1415.4	1240.7	63.35	135.54	97.11	64.43	636.86	340.53
Total solid excrement	2802.8	418.2	37.18	51.23	51.23	34.63	213.03	82.13
Total digested		822.5	26.17	84.31	45.88	29.80	423.83	258.40
Per cent. digested		66.29	41.31	62.20	47.23	46.25	66.55	75.88
Mean of both animals		63.09	29.47	60.83	45.14	46.69	64.53	70.38
*Mean digestibility of pulled corn fodder (two animals)		55.53	13.48	55.95	52.53	63.00	58.86	60.65

Mean nutritive ratio of sorghum fodder 1:8.94.
*Mean nutritive ratio of corn fodder 1:8.73.

*Bulletin 87d, p. 7, N. C. Experiment Station.

It may be noted that although the correspondence between the percentages digested by the goat and cow is very close for protein and fat, it is rather wider for carbohydrates, and rather wide in ash. The cow seems to have digested this fodder rather better than did the goat.

In the digestion of pulled fodder from corn this goat digested protein and fat better than the sheep but fell behind the sheep in dry matter and carbohydrates, much as in this trial with sorghum fodder. While the mean digestibility of the pulled corn fodder differs in some respects considerably from that of sorghum fodder as found in the duplicated trials of each fodder, the real digestibility is doubtless nearer alike than appears from the comparison of means

afforded by the table. The sheep seemed less able to digest protein in the pulled corn fodder than the goat, and at the same time to surpass the goat in digesting carbohydrates, a difference which materially affects our comparison of mean coefficients. In the same way in the present trial the cow differs from the goat, but in a less degree, and the coefficients for cow and goat are no farther apart than might be found in duplicate trials with either animal.

V. DIGESTION OF PEANUT-VINE HAY,

BY BLACK AND GRAY GOATS.

Date of experiment, April, 1893.

Daily ration { Black goat, 900 grams. / Gray goat, 900 grams.

Total period, 14 days.

Collection period, the last 5 days.

Analytical and other data for obtaining coefficients of digestibility are contained in Tables IX and X.

The peanut-vine hay subjected to digestion in this experiment was in good condition and contained a considerable lot of "puffs" and some peanuts containing good meats. It was raised in a sandy soil in Edgecombe County upon the farm of Messrs. Battle & Howard.

This hay was eaten very well, and one goat maintained his weight on it while the other fell off a little. The percentages digested are very uniform, and show this part of the peanut plant in a very favorable light. The ratio is narrow enough to indicate this as a good coarse food and nearly a balanced ration in itself, indeed upon such a ration an animal may gain in a long period at smaller cost than could be obtained by a balanced ration and greater expense for a shorter time.

TABLE IX.—Showing percentage Composition of Peanut-vine Hay, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumin'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract	Crude fiber.
Peanut-vine hay	10.44	89.56	7.59	11.52	9.12	3.99	47.92	28.98
Waste, peanut-vine hay, gray goat	11.16	88.84	8.87	13 59	10.56	4.13	47.38	26.03
Waste, peanut-vine hay, black goat	12.54	87.46	6 57	10.26	8.75	4.44	44 35	34.38
Solid excrement, gray goat	52.22	47.78	14.19	10.08	10.08	3.76	36.34	35.69
Solid excrement, black goat	45.82	54 18	15.36	10 56	10.56	3.03	36.57	34.48

TABLE X.—Showing Nutrients Consumed and Excreted in Grams with percentages Digested.

GRAY GOAT.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Peanut-vine hay fed	4500.0	4030.2	305.90	464.28	367.55	160.80	1931.27	1167.95
Waste, peanut-vine hay	837.0	743.6	65.95	101.05	78.52	30.71	352.31	193.56
Total consumed		3286.6	239.95	363.23	289.03	130.09	1578.96	974.39
Total solid excrement	2788.0	1332.1	189.0	134.27	134.27	49.28	484.08	475.43
Total digested		1954.5	50.95	228.96	154.76	80.81	1094.88	498.96
Per cent. digested		59.46	21.24	63.03	51.92	62.12	69.34	51.20

BLACK GOAT.

Peanut-vine hay fed	4500.0	4030.2	305.90	464.28	367.55	160.80	1931.27	1167.95
Waste, peanut-vine hay	41.0	35.9	2.36	3.68	3.15	1.59	15.92	12.35
Total consumed		3994.3	303.54	160.60	364.40	159.21	1915.35	1155.60
Total solid excrement	2930.4	1588.0	243.90	167.69	167.69	48.12	580.73	547.54
Total digested		2406.3	59.64	292.91	196.71	111.09	1334.62	608.06
Per cent. digested		60.24	19.65	63.59	53.98	69.77	69.67	52.61
Mean of both animals		59.85	20.44	63.31	52.95	65.94	69.50	51.90

Mean nutritive ratio of peanut-vine hay 1:7.69.

VI. DIGESTION OF SORGHUM BAGASSE,

BY GRAY GOAT.

Date of experiment, February, 1893.

Daily ration, 900 grams, but only small portion was eaten.

Total period, 15 days.

Collection period, the last 5 days.

Analytical and other data for obtaining coefficients of digestibility are contained in Tables XI and XII.

The composition of the materials used in experiments VI and VII are shown in Table XI and the discussion of the results of the two experiments follow Table XIII.

TABLE XI.—Showing percentage Composition of Sorghum Bagasse, Cotton-seed Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract	Crude fiber.
Sorghum bagasse	11.25	88.75	3.24	3.87	3.40	1.62	56.87	34.40
Cotton-seed meal	7.03	92.97	6.20	42.33	41.65	12.73	31.77	6.97
Waste, sorghum bagasse, 1st experiment	11.96	88.04	3.14	4.27	3.69	1.72	55.23	35.64
Waste, sorghum bagasse, 2d experiment	11.26	88.74	4.07	4.75	4.06	1.81	55.82	33.55
Solid excrement, 1st experiment	51.47	48.53	7.23	8.07	8.07	2 14	51.44	31.12
Solid excrement, 2d experiment	51.25	48.75	9.08	10.03	10.03	2.24	48.15	30.50

TABLE XII.—Showing Nutrients Consumed and Excreted in Grams with percentages Digested.

GRAY GOAT. FIRST EXPERIMENT, SORGHUM BAGASSE ALONE.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.35)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Sorghum bagasse fed	4500.0	3993.75	129.40	154.56	135.79	64.70	2271.24	1373.85
Waste, sorghum bagasse	1451.5	1277.90	40.13	54.57	47.15	21.98	705.78	455.44
Total consumed	3048.5	2715.85	89.27	99.99	88.64	42.72	1565.46	918.41
Total solid excrement	2204.5	1069.84	77.35	86.34	86.34	22.89	550.33	332.93
Total digested		1646.01	11.92	13.65	2.30	19.83	1015.13	585.48
Per cent. digested		60.60	13.35	13.65	2.59	46.42	64.84	63.75

VII. DIGESTION OF SORGHUM BAGASSE AND COTTON SEED MEAL,

BY GRAY GOAT.

Date of experiment, February and March, 1893.
Total period, 14 days.
Collection, the last 5 days.
Bagasse and meal fed in proportion of 4 to 1.
Bagasse and meal eaten in proportion of 1.86 to 1.
Analytical and other data for obtaining the coefficients of digestibility are presented in Tables XI and XIII.

TABLE XIII.—Showing Nutrients Consumed and Excreted in Grams with Percentages Digested.

GRAY GOAT. SECOND EXPERIMENT, RATION SORGHUM BAGASSE AND COTTON-SEED MEAL. FED 4 TO 1; EATEN 1.86 TO 1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Sorghum bagasse fed	4500.0	3993.75	129.40	154.56	135.79	64.70	2271.24	1373.85
Cotton-seed meal fed	1125.0	1045.91	64.85	442.73	435.62	133.14	332.29	72.90
Total fed	5625.0	5039.66	194.25	597.29	571.41	197.84	2603.53	1446.75
Waste, sorghum bagasse	2404.5	2133.75	86.84	101.35	86.63	38.62	1191.06	715.87
Total consumed	3220.5	2905.91	107.41	495.94	484.78	159.22	1412.47	730.88
Total solid excrement	2254.1	1098.87	99.78	110.21	110.21	24.61	529.11	335.15
Total digested		1807.04	7.16	385.72	374.57	134.60	883.36	395.72
Digested from sorghum bagasse		1127.16	5.68	7.26	1.27	12.11	700.39	419.46
Digested from Cotton-seed meal		679.88	1.95	378.46	373.30	122.49	182.97	
Per cent. of ration digested		62.18	7.10	77.77	77.27	84.54	62.54	54.14
Per cent. of cotton-seed meal digested in ration		65.00	3.01	85.48	85.69	92.01	55.06	

Nutritive ratio of sorghum bagasse, 1:120.8.

Nutritive ratio of ration of 1 pound cotton-seed meal to 1.86 pounds sorghum bagasse, 1:4.19.

This Station has grown several varieties of sorghum for two years, and distributed the seed among the farmers of the State not needed for the production of seed. Enough cane was produced in 1892 to make a small quantity of syrup. When the sorghum canes were ground, some of the bagasse was dried for this experiment. The fodder was also preserved for feeding and digestion. The goat ate sparingly of this food which was dry, hard, and uninviting. The juice had been thoroughly removed when the canes were ground and consequently was not very sweet after having been dried. Sorghum bagasse, when fresh, is sweet, to the taste and may be fed to some extent very readily, as cattle accept it more or less according to the thoroughness with which the juice is removed. When the expression of juice is thoroughly done, the bagasse is least attractive to animals; but when poorly done and much juice is left, it is most greedily eaten.

The bagasse under trial was nearly free from juice. The composition when analyzed was found to be very much like that of cotton-seed hulls. It contains less protein, fat, and crude fiber, and more nitrogen-free extract.

The close correspondence between the composition of bagasse and cotton-seed hulls points toward something in kind in the digestibility. This single determination marks the sorghum bagasse much more digestible than are cotton-seed hulls except in the fat, of which the hulls yield up a high percentage to the digestive fluids while but little "ether extract" present in the bagasse is digestible.

The percentages of this by-product digested are encouraging, in that they show a large amount of digestible carbohydrates which can easily be balanced by cotton-seed meal and thus produce very good cattle rations. If bagasse can be preserved in silos, and there is no reason why it cannot, sorghum growers and syrup makers on a large scale have a very cheap and valuable waste product to turn into growth of young stock and into beef.

A quantity of bagasse, from which juice was poorly removed, put into the bottom of one of the Station silos under corn, came out in good condition. Another lot, pressed out dryer, and stored on the top of another silo of corn, was too dry and was only fit for bedding and for mulching.

VIII. DIGESTION OF CRIMSON CLOVER HAY, ONE YEAR OLD,

BY BLACK GOAT AND COW, MISS HALEY.

Date of experiment, January, 1893.
Daily ration for goat, 3 pounds fed, 2.47 pounds eaten.
Daily ration for cow, 18 pounds fed, 15.07 pounds eaten.
Total period, 12 days for goat, and 13 days for cow.
Collection period, the last 5 days.
Analytical and other data for obtaining the coefficients of digestibility are contained in Tables XIV and XV.

TABLE XIV.—Showing Percentage Composition of Crimson Clover Hay, (one-year-old), Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumin'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay	11.46	88.54	7.08	17.00	13.90	2.27	43.46	30.19
Waste, crimson clover hay, native cow, Miss Haley	10.52	89.48	8.82	22.20	18.62	2.38	45.83	20.77
Waste, crimson clover hay, black goat	9.79	90.21	8.24	15.51	12.25	2.95	45.77	27.53
Solid excrement, native cow, Miss Haley	83.30	16.70	6.36	13.88	13.88	3.16	37.75	38.85
Solid excrement, black goat	58.16	41.84	7.67	13.44	13.44	3.19	36.33	39.37

TABLE XV.—Showing Nutrients Consumed and Excreted in Ounces† with percentages Digested.

NATIVE COW, MISS HALEY.

	Total amount.	DRY MATTER CONTAINS						
		Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay (one-year-old) fed	1440.0	1275.0	90.27	216.75	177.23	28.94	554.12	384.92
Crimson clover hay, waste	235.4	210.6	18.57	46.75	39.21	5.01	96.52	43.74
Total consumed	1205.6	1064.4	71.70	170.00	138.02	23.93	457.60	341.18
Total solid excrement	2202.1	367.8	23.39	51.05	51.05	11.62	138.84	142.89
Total digested	.....	696.6	48.31	118.95	86.97	12.31	318.76	198.29
Per cent. digested	.....	65.44	67.37	69.97	63.01	51.44	69.66	58.12

BLACK GOAT.

Crimson clover hay (one-year-old) fed	240.00	212.50	15.05	36.13	29.54	4.82	92.35	64.15
Crimson clover hay, waste	42.18	38.05	3.14	5.90	4.66	1.12	17.42	10.48
Total consumed	197.82	174.45	11.91	30.23	24.88	3.70	74.93	53.67
Total solid excrement	180.17	75.38	5.78	10.13	10.13	2.40	27.39	29.68
Total digested	.....	99.07	6.13	20.10	14.75	1.30	47.54	23.99
Per cent. digested	.....	56.79	51.47	66.49	59.28	35.13	63.44	44.69
Mean of both animals (one-year-old hay)	.....	61.11	59.42	68.23	61.14	43.28	66.55	51.40
*Mean of two animals (new hay)	.....	62	53.55	69.14	60.23	48.83	71.49	48.70

Mean nutritive ratio of one-year-old crimson clover hay, 1:4.47.
*Mean nutritive ratio new crimson clover hay, 1:3.76.

†One ounce, 28 35 grams.
*Bulletin 87d. Technical Bulletin No. 4, p. 9, N. C. Experiment Station.

The crimson clover hay fed in these experiments had been cut and stored in barn for more than a year, it being a portion of the same lot of hay, the digestibility of which was determined a year ago. Comparison of the compositions of the new and one-year-old hay shows a decrease of one per cent. in total protein but practically the same amount of albuminoids, slightly less fat, and an increase of nitrogen-free extract and crude fiber in the year-old hay. The new hay was slightly more digestible than the old; the decrease in the old hay falling upon the fat and nitrogen-free extract, but the difference in digestibility of total dry matter in the old and new hay is no more than would be expected to be found in different experiments with exactly the same food. The digestibility of the old hay was determined to see if it had deteriorated with age, and to use in rations to determine the digestibility of cotton-seed meal, corn meal, and corn and cob meal which follow later.

IX. DIGESTION OF CRIMSON CLOVER HAY AND COTTON-SEED MEAL,

BY COW, MISS HALEY AND GRAY GOAT.

Date of experiment, January, 1893.

Daily ration:

- Cow, "Miss Haley,"
  - 18 lbs. hay and 2¼ lbs. meal fed.
  - 14.43 lbs. hay and 2¼ lbs. meal eaten.
  - Proportion of hay to meal eaten, 6.4 to 1.
- Gray Goat,
  - 36 ounces hay and 9.0 ounces meal fed.
  - 27.81 ounces hay and 9.0 ounces meal eaten.
  - Proportion of hay to meal eaten 3.09 to 1.

Total periods, 16 days for Miss Haley, and 13 days for gray goat.

Collection period, the last 5 days for cow and last 4 days for goat.

Analytical and other data for obtaining the coefficients of digestibility are presented in Tables XVI and XVII.

TABLE XVI.—Showing percentage Composition of Crimson Clover Hay, Cotton-seed Meal, Waste, and Solid Excrement.

	Water.	DRY MATTER CONTAINS						
		Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay	11.46	88.54	7.08	17.00	13.90	2.27	43.46	30.19
Cotton-seed meal	7.03	92.97	6.20	42 33	41.65	12.73	31.77	6.97
Waste, crimson clover hay, cow, Miss Haley	16.27	83.73	8.35	21.05	18.53	3.30	45.27	22.03
Waste, crimson clover hay, gray goat	11.00	89.00	8 08	19.28	16.56	2.60	47.26	22.78
Solid excrement, cow, Miss Haley	82.97	17.03	8.04	13.37	13.37	2.96	39.05	36.58
Solid excrement, gray goat	58.87	41.13	9.18	12.95	12.95	3.60	39.01	35.26

The clover hay fed in these experiments was the same as that the digestibility of which was determined in the previous experiment, No. 8. The digestibility of the hay having been determined, it was fed with cotton-seed meal, and from the digestibility of the hay and the ration the digestibility of the cotton-seed meal was calculated. It was the original plan, in the experiments which precede and follow, to determine the digestibility of cotton-seed meal, to feed the meal and hay in two proportions, viz.: 1 to 8 and 1 to 4. The object being to ascertain if the coefficients for the meal in the two rations would agree. The animals, however, did not eat the rations as they were fed, and the original plan was somewhat interfered with. All the results will be considered after the presentation of the next two

experiments. It should be said that the digestibility of the ration of 8 pounds hay to 1 pound meal (fed) was determined in duplicate, but the results of one experiment were considered erroneous and for that reason are withheld from publication.

TABLE XVII.—Showing Nutrients Consumed and Excreted in Ounces*, with Percentages Digested.

COW, MISS HALEY. RATION: CRIMSON CLOVER HAY AND COTTON-SEED MEAL 6.4 TO 1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay fed	1440.0	1275.0	90.27	216.75	177.23	28.94	554.12	384.92
Cotton-seed meal fed	180.0	167.3	10.37	70.82	69.68	21.30	53.15	11.66
Total fed	1620.0	1442.3	100.64	287.57	246.91	50.24	607.27	396.58
Waste, crimson clover hay	285.5	239.0	19.96	50.31	44.29	7.89	108.20	52.65
Total consumed	1334.5	1203.3	80.68	237.26	202.62	42.35	499.07	343.93
Total solid excrement	2691.9	458.4	36.86	61.29	61.29	13.56	179.01	167.68
Total digested		744.9	43.82	175.97	141.33	28.79	320.06	176.25
Digested from crims'n clover hay		633.1	41.77	113.56	81.28	9.11	296.76	170.79
Digested from cotton-seed meal		111.8	2.05	62.41	60.05	19.68	23.30	5.46
Per cent. of ration digested		61.90	54.31	74.17	69.75	67.98	64.13	51.24
Per cent. of cotton-seed meal digested		66.82	19.77	88.12	86.18	92.39	43.84	46.83

GRAY GOAT. RATION: CRIMSON CLOVER HAY AND COTTON-SEED MEAL 3.09 TO 1.

Crimson clover hay fed	144.00	127.50	9.03	21.68	17.72	2.89	55.41	38.49
Cotton-seed meal fed	36.00	33.47	2.08	14.17	13.94	4.26	10.63	2.33
Total fed	180.00	160.97	11.11	35.85	31.66	7.15	66.04	40.82
Waste, crimson clover hay	32.76	29.16	2.36	5.62	4.83	.76	13.78	6.64
Total consumed	147.24	131.81	8.75	30.23	26.83	6.39	52.26	34.18
Total solid excrement	106.03	43.61	4.00	5.65	5.65	1.57	17.01	15.38
Total digested		88.20	4.75	24.58	21.18	4.82	35.25	18.80
Digested from crims'n clov'r hay		60.10	3.96	10.96	7.88	.92	27.70	16.37
Digested from cotton-seed meal		28.10	.79	13.62	13.30	3.90	7.55	2.43
Per cent. of ration digested		66.91	54.28	81.31	78.94	75.43	67.45	55.00
Per cent. of cotton-seed meal digested		83.95	37.98	96.12	95.41	91.55	71.02	100.00

Nutritive ratio of ration of 6.4 pounds crimson clover hay to 1 pound cotton-seed meal, 1 to 3.73.

Nutritive ratio of ration of 3.09 pounds crimson clover hay to 1 pound cotton-seed meal, 1 to 2.68.

*One ounce, 28.35 grams.

X. DIGESTION OF CRIMSON CLOVER HAY AND COTTON-SEED MEAL,

BY GRADE JERSEY COW, "SPOT."

Date of experiment, January and February, 1893.

Daily ration:

- First period,
  - 18 pounds hay and 4½ pounds meal fed.
  - 15.74 pounds hay and 4½ pounds meal eaten.
  - Proportion of hay to meal eaten 3.5 to 1.
- Second period,
  - 18 pounds hay and 4½ pounds meal fed.
  - 15.88 pounds hay and 4½ pounds meal eaten.
  - Proportion of hay to meal eaten 3.53 to 1.

Total periods, 27 days; 13 for first and 14 for second.

Collection periods, the last 4 days for first; and the last 5 days for second.

Analytical and other data for obtaining the coefficients of digestibility are presented in Tables XVIII and XIX.

Three determinations of digestibility of the ration of 4 pounds clover hay to 1 pound cotton-seed meal (fed) were made, the results of two determinations being presented in Table XIX and those of the third in Table XVII along with the results for the 8 to 1 ration. It was hoped to obtain from these two sets of experiments some evidence as to whether the clover hay or cotton-seed meal exerted any influence on the digestibility of the other in the rations, but the calculated coefficients for cotton-seed meal, even in the same ration, are too wide to allow any conclusions to be drawn. The coefficients of digestibility of the rations are quite concordant, but since the meal

TABLE XVIII.—Showing percentage Composition of Crimson Clover Hay, Cotton-seed Meal, Waste and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N ×6.25)	Albumids (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay	11.46	88.54	7.08	17.00	13.90	2.27	13.46	30.19
Cotton-seed meal	7.03	92.97	6.20	42.33	41.65	12.73	31.77	6.97
Waste, crimson clover hay, grade Jersey cow, "Spot," 1st period	10.08	89.92	7.95	17.79	14.80	2.59	43.78	27.89
Waste, crimson clover hay, 2d period	15.56	84.44	8.64	17.46	13.75	2.85	41.65	29.40
Solid excrement, grade Jersey cow, "Spot," 1st period	81.05	18.95	8.23	15.50	15.50	3.54	38.36	34.37
Solid excrement, 2d period	84.59	15.41	8.73	15.89	15.89	3.76	36.70	34.92

TABLE XIX.—Showing Nutrients Consumed and Excreted in Ounces*, with percentages Digested.

GRADE JERSEY COW, SPOT, 1ST PERIOD. RATION: CRIMSON CLOVER HAY AND COTTON-SEED MEAL, 3.5 to 1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds Alb, N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay fed	1152.0	1020.0	72.22	173.40	141.78	23.15	443.29	307.94
Cotton-seed meal fed	288.0	267.7	16.60	113.32	111.50	34.08	85.05	18.66
Total fed	1440.0	1287.7	88.82	286.72	253.28	57.23	528.34	326.60
Waste, crimson clover hay	144.3	129.8	10.32	23.09	19.21	3.36	56.83	36.20
Total consumed	1295.7	1157.9	78.50	263.63	234.07	53.87	471.51	290.40
Total solid excrement	2286.6	433.3	35.66	67.16	67.16	15.34	166.21	148.93
Total digested		724.6	42.84	196.47	166.91	38.53	305.30	141.47
Digested from crimson clover hay		544.0	36.78	102.56	74.94	8.57	257.18	139.67
Digested from cotton-seed meal		180.6	6.06	93.91	91.97	29.96	48.12	1.80
Per cent. of ration digested		62.57	54.57	74.52	71.31	71.52	64.75	48.71
Per cent. of cotton-seed meal digested		67.46	36.50	82.87	82.48	87.91	56.58	9.64

GRADE JERSEY COW, SPOT, 2D PERIOD. RATION: CRIMSON CLOVER HAY AND COTTON-SEED MEAL, 3.5 TO 1.

Crimson clover hay fed	1440.0	1275.0	90.27	216.75	177.23	28.94	554.12	384.92
Cotton-seed meal fed	360.0	334.6	20.74	141.64	139.36	42.60	106.30	23.32
Total fed	1800.0	1609.6	11.01	358.39	316.59	71.54	660.42	408.24
Waste, crimson clover hay	169.5	143.1	12.36	24.99	19.68	4.08	59.60	42.07
Total consumed	1630.5	1466.5	98.65	333.40	296.91	67.46	600.82	366.17
Total solid excrement	3402.1	524.3	45.77	83.31	83.31	19.71	192.42	183.09
Total digested		942.2	52.88	250.09	213.60	47.75	408.40	183.08
Digested from crimson clover hay		691.7	46.29	130.84	96.33	10.75	329.10	176.22
Digested from cotton-seed meal		250.5	6.59	119.25	117.27	37.00	79.30	6.86
Per cent. of ration digested		64.25	53.60	75.01	71.94	70.78	67.97	50.00
Per cent. of cotton-seed meal digested		74.86	31.77	84.19	84.15	86.85	74.60	29.41
Mean per cent. of above two rations digested		63.41	54.08	74.77	71.62	71.15	66.36	49.35
Mean per cent. of cotton-seed meal digested in four experiments		73.3	31.5	87.8	87.1	89.7	61.5	46.4

Mean nutritive ratio of rations of 3.5 and 3.53 pounds crimson clover hay to 1 pound cotton-seed meal, 1 to 2.81.

*One ounce, 28.35 grams.

forms rather a small part of the rations and all differences in digestibility of rations from whatever cause fall upon the calculated coefficients for meal, they have been made quite divergent. It is considered, however, that the average results presented at the foot of Table XIX gives a fairly correct idea of the digestibility of cotton-seed meal. The digestibility of cotton-seed meal has also been determined by Wolff and Armsby. Their work was done upon the meal of ten years ago; and that used by Armsby, as shown by analysis,* contained more oil and *much less fiber* than the meals of the present day, which means that the oil is more completely removed by modern machinery and indicates that either the hulls and kernels are not so well separated now, or else hulls are ground in with the meal. We present below the results of Wolff and Armsby,* and those obtained at this Station for the digestibility of cotton-seed meal.

	Wolff's experiments.	Armsby's experiments.	Average of Wolff's and Armsby's.	Our experiments.	Average of all.
Dry matter	74.0	81.5	77.8	73.3	76 3
Protein	84.7	88.8	86.8	87.5	87.1
Albuminoids	....	....	....	87.1	....
Fat	87.6	100.0	93.8	89.7	92.4
Nitrogen-free extract	83.7	68.9	76.3	61.5	71.4
Crude fiber	0.0	0.0	0.0	46.4	....

*Bulletin No. 3, Wisconsin Experiment Station.

XI. DIGESTION OF COTTON-SEED HULLS AND MEAL IN RATIONS 3 TO 1 AND 2.8 TO 1,

BY OLD STEERS LOPHORN AND YELLOW 2d.

Date of the experiment, January and February, 1892.

Daily ration offered, { 18 pounds hulls and 6 lbs. of meal to Yellow. / 21 pounds hulls and 7½ lbs. meal to Lophorn. } all consumed.

Total period, 18 days.

Collection period, the last 5 days.

Analytical and other data for obtaining the coefficients of digestibility are given in Tables XX and XXI.

This is a continuation of the digestion experiments in narrowing the ratio between hulls and meal fed. The steers to which these rations were fed took on fat and throve under the heavy feeding of

cotton-seed meal and were carried forward to the next experiment in good condition. It will be noted that the nutritive ratios have been narrowed to about the German standard for fattening in these trials of feeding, in the proportion of 3 pounds of hulls to 1 pound of meal. A little waste hulls would vary the ration toward the standard for a second fattening period, while addition of a little more of hulls would reach the wider ratio for the first fattening period. Compared with digestion of ration of four pounds of hulls to one of meal, about the same amount of total dry matter is shown to be digested, more protein and albuminoids, about the same per cent. of fat, less nitrogen-free extract, and more crude fiber. This difference in the relations of the amounts of the various constituents digested tends to a narrowing of the nutritive ratio.

TABLE XX.—Showing Percentage Composition of Cotton-seed Hulls, Cotton-seed Meal, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6 25)	Albumi'ds (Alb. N ×6.25)	Fats (Ether extract)	N-free extract.	Crude fiber.
Cotton-seed hulls	12.35	87.65	1 88	4 82	4.82	3.13	40.57	49.60
Cotton-seed meal	7.03	92.97	6.20	42.33	41.65	12.73	31.77	6.97
Solid excrement, steer, Yellow 2d	71.36	28 64	4.75	12.66	12 66	1.63	37.96	43.00
Solid excrement, Lophorn steer	75.90	24 10	4 24	11 76	11.76	1.88	37.98	44.14

TABLE XXI.—Showing Nutrients Consumed and Excreted in Ounces*, with Percentages Digested.

STEER, YELLOW 2D. RATION: COTTON-SEED HULLS AND MEAL, 3:1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Cotton-seed hulls fed	1440.0	1262.2	23.73	60.84	60.84	39.51	512.07	626.05
Cotton-seed meal fed	480.0	446.3	27.67	188.92	185.88	56.81	141.79	31.11
Total consumed	1920.0	1708.5	51.40	249.76	246.72	96.32	653.86	657.16
Total solid excrement	2687.5	769.7	36.56	97.44	97.44	12.55	292.18	330.97
Total digested		938.8	14.84	152.32	149.28	83.77	361.68	326.19
Digested from cotton-seed meal		327.1	8.72	165.87	161.90	50.96	87.20	14.44
Digested from cotton-seed hulls		611.7	6.12	-13.55	-12.62	32.81	274.48	311.75
Per cent. of ration digested		54.95	28.87	60.98	60.50	86.96	55.31	49.63
Per cent. of cotton-seed hulls digested		48.46	25.79			83.04	53.60	49.79

*One ounce, 28.35 grams.

TABLE XXI.—Showing Nutrients Consumed and Excreted in Ounces*, with Percentages Digested—Continued.

LOPHORN STEER. RATION: COTTON-SEED HULLS AND MEAL, 2.8:1.

		DRY MATTER CONTAINS						
	Total amount.	Dry matter.	Ash.	Protein (N×6.25)	Albumi'd- (Alb. N ×6.25)	Fats. (Ether extract.)	N-free extract.	Crude fiber.
Cotton-seed hulls fed	1680.0	1472.5	27.68	70.97	70.97	46.09	597.39	730.36
Cotton-seed meal fed	600.0	557.8	34.58	236.12	232.32	71.01	177.21	38.88
Total consumed	2280.0	2030.3	62.26	307.09	303.29	117.10	774.60	769.24
Total solid excrement	4082.3	983.8	41.71	115.69	115.69	18.50	373.65	434.25
Total digested		1046.5	20.55	191.40	187.60	98.60	400.95	334.99
Digested from cotton-seed meal		408.9	10.89	207.31	202.35	63.69	108.98	18.04
Digested from cotton-seed hulls		637.6	9.66	-15.91	-14.75	34.91	291.97	316.95
Per cent. of ration digested		51.54	33.01	62.33	61.82	84.20	51.76	43.55
Per cent. of cotton-seed hulls digested		43.30	34.89			75.74	48.88	43.39

Nutritive ratio of ration of 3 pounds cotton-seed hulls to 1 pound cotton-seed meal, 1 to 5.89.

Nutritive ratio of ration of 2.8 pounds cotton-seed hulls to 1 pound cotton-seed meal, 1 to 5.13.

*One ounce, 28.35 grams.

XII. DIGESTION OF COTTON-SEED HULLS AND MEAL IN RATIONS OF 2 TO 1,

BY OLD STEERS LOPHORN AND YELLOW 2D.

Date of the experiment, February, 1893.

Total period for first part of ration 2 to 1, 14 days.

Collection period, the last 5 days.

Rations fed, { Lophorn, 21 pounds hulls 10½ pounds meal. / Yellow 2d, 18 pounds hulls 9 pounds meal.

Lophorn left waste which reduced the ratio eaten to 2.4 to 1. Yellow 2d ate the ration clean for 35 days to the end of the digestion period with it, and continued to eat it until changed on the 58th day. Lophorn ate heartily all the time but never cleaned his feed-box well. The steers remained in good condition throughout all the feeding.

Analytical and other data for obtaining the coefficients of digestibility are given in Tables XXII and XXIII.

This is heavy feeding with cotton-seed meal. The proportion of the ration digested has ceased increasing. This may be due to the heavy ration having carried more nutriment than the steer could

TABLE XXII.—Showing Percentage Composition of Cotton-seed Hulls and Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Cotton-seed hulls	12.35	87.65	1.88	4.82	4.82	3.13	40.57	49.60
Cotton-seed meal	7.03	92.97	6.20	42 33	41.65	12.73	31.77	6.97
Waste, cotton-seed hulls, Lophorn steer	8.96	91.04	4.55	29.04	27.19	9.88	30.92	25.61
Waste, cotton-seed meal, Lophorn steer	7.82	92.18	5.93	40.75	40.12	14.42	30.01	8.89
Waste, cotton-seed meal, Yellow 2d, 1st experiment	8.58	91.42	6.33	44.07	43.81	14.98	28.35	6.73
Solid excrement, Lophorn steer	76.90	23.10	4.64	12.94	12.94	2.00	36.91	43.51
Solid excrement, Yellow 2d, 1st experiment	71.44	28.56	5.45	13.56	13.56	3.04	45.51	34.44
Solid excrement, Yellow 2d, 2d experiment	72.23	27.77	5.16	13.47	13 47	1.83	37.96	41.58

TABLE XXIII.—Showing Nutrients Consumed and Excreted in Ounces* with Percentages Digested.

LOPHORN STEER. RATION: COTTON-SEED HULLS AND MEAL, 2.4:1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds. Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Cotton-seed hulls fed	1680.0	1472.5	27.68	70.97	70.97	46.09	597.39	730.36
Cotton-seed meal fed	840.0	780.9	48.42	330.55	325.24	99.41	248.09	54.43
Total fed	2520.0	2253.4	76.10	401.52	396.21	145.50	845.48	784.79
Waste, cotton-seed hulls	26.5	24.1	1.10	7.00	6.55	2.38	7.45	6.17
Waste, cotton-seed meal	153.1	141.1	8.37	57.50	56.61	20.34	42.34	12.54
Total waste	179.6	165.2	9.47	64.50	63.16	22.72	49.79	18.71
Total consumed	2340.4	2088.2	66.63	337.02	333.05	122.78	795.69	766.08
Total solid excrement	4335.0	1001.4	46.46	129.58	129.58	20.03	369.62	435.71
Total digested		1086.8	20.17	207.44	203.47	102.75	426.07	330.37
Digested from cotton-seed meal		468.9	12.62	239.74	233.98	70.93	126.54	19.44
Digested from cotton-seed hulls		617.9	7.55	-32.30	-30.51	31.82	299.53	310.93
Per cent. of ration digested		52.04	30.27	61.55	61.09	83.68	53.55	43.12
Per cent. of cotton-seed hulls digested		42.66	28 40			72.79	50.77	42.93

*One ounce, 28.35 grams.

TABLE XXIII.—Showing Nutrients Consumed and Excreted in Ounces*, with Percentages Digested—Continued.

YELLOW 2D. 1ST EXPERIMENT. RATION: COTTON SEED HULLS AND MEAL, 2.02:1.

		DRY MATTER CONTAINS						
	Total amount.	Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb, N ×6.25)	Fats, (Ether extract)	N free extract.	Crude fiber.
Cotton-seed hulls fed	1440.0	1262.2	23.73	60.84	60.84	39.51	512.07	626.05
Cotton-seed meal fed	720.0	669.4	41.50	283.35	278.81	85.21	212.67	46.66
Total fed	2160.0	1931.6	65.23	344.19	339.65	124.72	724.74	672.71
Waste, cotton-seed meal	7.4	6.8	.43	3.00	2.98	1.02	1.91	.46
Total consumed	2152.6	1924.8	64.80	341.19	336.67	123.70	722.83	672.25
Total solid excrement	3244.0	926.5	50.49	125.63	125.63	28.17	403.12	319.09
Total digested		998.3	14.31	215.56	211.04	95.53	319.71	353.16
Digested from cotton-seed meal		485.7	12.94	246.15	240.25	75.52	129.62	21.44
Digested from cotton-seed hulls		512.6	1.37	−30.59	−29.21	20.01	190.09	331.72
Per cent. of ration digested		51.86	22.08	63.18	62.68	77.22	44.23	52.53
Per cent. of cotton seed hulls digested		40.61	5.77			50.64	37.12	52.98

YELLOW 2D, 2D PERIOD. RATION: COTTON-SEED HULLS AND MEAL, 2:1.

Cotton-seed hulls fed	1440.0	1262.2	23.73	60.84	60.84	39.51	512.07	626.05
Cotton-seed meal fed	720.0	669.4	41.50	283.35	278.81	85.21	212.67	46.66
Total consumed	2160.0	1931.6	65.23	344.19	339.65	124.72	724.74	672.71
Total solid excrement	3114.2	864.8	44.62	116.49	116.49	15.83	328.28	359.58
Total digested		1066.8	20.61	227.70	223.16	108.89	396.46	313.13
Digested from cotton-seed meal		490.7	13.07	248.78	242.84	76.43	130.79	21.65
Digested from cotton-seed hulls		576.1	7.54	−21.08	−19.68	32.46	265.67	291.48
Per cent. of ration digested		55.23	31.59	66.16	65.70	87.30	54.70	46.54
Per cent. of cotton-seed hulls digested		45.64	31.77			82.16	51.88	46.56
Mean of two trials on ration by Yellow 2d		53.55	26.84	64.67	64.19	82.26	49.47	49.53

Nutritive ratio of ration consumed as 2.4 pounds cotton-seed hulls to 1 pound cotton-seed meal, 1:4.88.

Mean nutritive ratio of ration consumed as 2 pounds cotton-seed hulls to 1 pound cotton-seed meal, 1:4.27.

*One ounce, 28.35 grams.

well digest. If so, then a limitation of appetite and feeding in the same ratio might have carried the increasing digestibility of hulls with relatively increasing amounts of cotton-seed meal farther than has been found. As far as carried, the digestibility of cotton-seed hulls reached a maximum when there were three pounds of hulls

eaten to one pound of cotton-seed meal. This is more plainly shown in Table XXIV than in the tables containing the usual data.

The digestibility of the cotton-seed hulls fed in these experiments with cotton-seed meal has been calculated by using the coefficients obtained for the cotton-seed meal from the experiments with crimson clover hay and cotton-seed meal (Nos. 9 and 10 of this bulletin). The minus percentages shown for protein in Table XXIV indicate the retardation of the digestibility of the protein of the meal fed in per cent. of that fed in the hulls. It is as though no protein has been digested from the hulls while they have retarded the digestibility of the protein of the meal, as fed with the clover hay, by an amount ranging from 12.6 per cent. of the protein contained in the hulls with the ration 7 to 1, to 50.49 per cent. of the protein contained in the hulls with the ration 2.4 to 1. But the loss in protein is more than counterbalanced by the increased digestibility of carbohydrates. The gains in nitrogen-free extract and crude fiber were sufficient to increase, after bringing up the loss from protein, the digestible dry matter from .81 per cent. in the 7 to 1 ration to 8.66 in the 3 to 1 ration.

TABLE XXIV.—Digestibility of Cotton-seed Hulls fed Alone and with Different Proportions of Cotton-seed Meal.

	Total dry matter.	Ash.	Protein (N×6.25)	Fat. (Ether extract)	N-free extract.	Crude fiber.
Average per cent. digested from cotton-seed hulls fed alone*	39.8	19.9	6.75	85.1	36.9	43.1
Per cent. digested from cotton-seed hulls consumed with meal in proportion of 7 to 1*	40.61	35.10	—12.60	78.41	50.24	33 52
Average per cent. digested from cotton-seed hulls when fed with meal in proportion of 6 to 1 with some waste assumed to have been all hulls*	41.12	22.02	—35.71	78.02	48.00	40.08
Per cent. digested from cotton-seed hulls when fed with meal in proportion of 4 to 1 with some waste assumed to have been all hulls*	47.72	59 01	—36.02	78.93	57.11	44.95
Per cent. digested from cotton-seed hulls when consumed with cotton-seed meal in proportion of 3 to 1	48.46	25.79	—22.27	83.04	53.60	49.79
Per cent. digested from cotton-seed hulls when consumed with cotton-seed meal in proportion of 2.8 to 1	43.30	34.89	—22.42	75.74	48.88	43.39
Per cent. digested from cotton-seed hulls when consumed with cotton-seed meal in proportion of 2.4 to 1	42.66	28.40	—50	49.72	79.50	77 42.93
Average per cent. digested from cotton-seed hulls when consumed with cotton-seed meal in proportion of 2 to 1	43.12	18.77	—42	46 66.40	44.50	49.77

*From Bulletin 87d, Tech. Bulletin No. 1, pp. 34–46, N. C. Experiment Station.

XIII. DIGESTIBILITY OF CORN SILAGE ALONE, AND IN RATIONS WITH COTTON-SEED MEAL.

Using the coefficients for cotton-seed meal obtained by us, the digestibility of corn silage in rations of corn silage and cotton-seed meal has been calculated and the results are presented along with the coefficients for silage when fed alone, in Table XXV. These figures indicate quite a decided increase in the digestibility of the silage from the presence of the meal. These results have been re-calculated from Bulletin 87d.

TABLE XXV.—Showing the Digestibility of Corn Silage when fed Alone and with Different Proportions of Cotton-seed Meal.

	Dry matter.	Ash.	Total Protein.	Albuminoids.	Fats.	N-free extract.	Crude fiber.
Per cent. of corn silage digested when fed alone*	53.17	26.89	34.41	26.39	66.04	60.53	43.17
Average per cent. of corn silage digested when fed with cotton-seed meal in proportion of 12 pounds fresh silage to 1 pound meal†	60.14	5.51	18.97	10.71	79.25	68.94	57.50
Per cent. corn silage digested when fed with cotton-seed meal and consumed in proportion of 8 pounds fresh silage to 1 pound meal‡	67.36	37.18	24.52	2.33	54.70	76.27	64.33

*Experiment No. 5, Bulletin 87d, Technical Bulletin No. 4, p. 15, N. C. Experiment Station.

†Experiment No. 8, Bulletin 87d, Technical Bulletin No. 4, p. 23, N. C. Experiment Station. The wastes in these two experiments were considered in making the above calculations as though they were all silage, but they contained a very small amount of cotton-seed meal as is shown by their compositions. The meal present would have had very little effect in changing the above figures.

‡Experiment No. 9, steer No. 1., Bulletin 87d, Technical Bulletin No. 4, p. 28, N. C. Experiment Station. Steer No. 2 was not used in this calculation on account of the large amount of mixed waste of silage and meal left by him. He digested practically the same from the ration as did steer No. 1.

XIV. DIGESTION OF CORN MEAL ALONE,

BY GRAY GOAT.

Date of experiment, April and May, 1893.

Daily ration, 600 grams corn meal; eaten 208.86 grams of meal.

Total period, 20 days.

Collections, the last 5 days.

Analytical and other data for obtaining coefficients of digestibility are given in Tables XXVI and XXVII.

TABLE XXVI.—Showing Percentage Composition Corn Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Corn meal	12.68	87.32	1.51	10 08	10.08	5.03	81.60	1.78
Waste, corn meal	11.75	88.25	1.86	10.37	10.37	4 87	80.68	2.22
Solid excrement	79.02	20.98	11.17	24.06	19.42	7 96	36.78	20 03

TABLE XXVII.—Showing Nutrients Consumed and Excreted in Grams with Percentages Digested.

GRAY GOAT.

	Total amount.	Dry matter.	DRY MATTER CONTAINS Ash.	Protein (N×6 25)	Albumi'ds (Alb. N ×6.25)	Fats (Ether extract)	N-free extract.	Crude fiber.
Corn meal fed	3000.0	2619.6	39.56	264.05	264.05	131.77	2137.59	46.63
Waste, corn meal	1955.7	1725.9	32.10	178.97	178.97	84.05	1392.46	38.31
Total consumed	..	893.7	7.46	85.08	85.08	47.72	745.13	8.32
Total solid excrement	558.0	117.1	13.08	28.17	22.74	9.32	43.07	23.46
Total digested	....	776.6	.....	56.91	62.34	38.40	702.06	.....
Per cent. digested	.....	86.89	..	66.89	73.27	80.47	94 22	.....

Nutritive ratio of corn meal 1:14.02.

The digestibility and relative feeding value of corn-and-cob meal, and corn meal were desired. The plan to obtain these was to feed both with crimson clover hay, the digestibility of which had been determined. Then the meals would be exchanged and fed to the same two animals to obtain one trial of each meal with each of the goats used for the digestion. Following this the gray goat was fed a period exclusively on corn meal, and the black goat on corn-and-cob meal.

The corn used was grown on a neighboring farm. It was a mixed sample of Dent corn, part being deep kernels on small cobs, and part shallow kernels on large cobs. The larger cobs showed some traces of mould in curing.

The goat did not eat the corn meal alone very readily, and the amount consumed is quite small as is also the dung excreted. The dung contained considerable mucus, and non-albuminoids to the amount of 4.64 per cent. of the total dung. Albuminoids were determined by the Stutzer method; finding soluble protein not precipitable by copper hydrate was rather a surprise, since all the protein of the corn meal fed was in the form of albuminoids, as is seen

from the analysis. In all the experiments with corn meal, corn-and-cob meal, and rations of these with crimson clover hay, soluble protein was present in the dungs, and to an extent that we think could hardly be accounted for by the presence of mucus, bile, and other intestinal products. In all the other experiments reported in this bulletin, albuminoids were determined in the dungs, and found to agree with total protein, and much narrower ratio rations of cotton-seed meal and hulls, and crimson clover hay were fed than those of corn meal and corn-and-cob meal and crimson clover hay. It would seem, therefore, that the albuminoids of the corn meal and corn-and-cob meal have undergone change in the digestive tract. In consequence of this, albuminoids in all the experiments with corn meal and corn and-cob meal have a real and an apparent digestibility and coefficients are presented for each; the greater and upper coefficients in the columns of albuminoids representing apparent digestibility; and the smaller ones, real digestibility. The real digestibility of albuminoids and that of protein in this trial with corn meal alone are the same, and are represented by the coefficient for protein, that for albuminoids being apparent. The coefficients for corn meal in this experiment make an excellent showing for it as a food. Especial attention is directed to the high digestibility of nitrogen-free extract, which is largely starch and forms 81.6 of the total dry matter of the corn meal.

XV. DIGESTION OF RATION OF CORN MEAL FED WITH CRIMSON CLOVER HAY,

BY GRAY GOAT AND BLACK GOAT.

Date of experiment, March and April, 1893.

Daily ration:

- Black goat, — Fed 900 grams hay, 300 grams meal; eaten 708.8 grams hay, 300 grams meal. Proportion of hay to meal eaten, 1.83 to 1.
- Gray goat, — Fed 900 grams hay, 300 grams meal; eaten 549.3 grams hay, 300 grams meal. Proportion of hay to meal eaten, 2.36 to 1.

Total period, 13 days for gray goat and 15 days for black goat. Collection period, the last 5 days in both cases.

Analytical and other data for obtaining the coefficients of digestibility are given in Tables XXVIII and XXIX.

A portion of the same corn meal fed in the previous trial of corn meal alone was used in this experiment, as also the same clover hay before reported. The goats were fed corn meal and crimson clover hay in the proportion of 3 to 1, but consumed them as 1.83 and 2.36 to 1. The coefficients of digestibility of the rations are quite high, and differ considerably, though not more so than often occur in experiments of this kind. The average coefficients make a most excellent showing for the digestibility of these rations.

The coefficients of digestibility of the corn meal in these rations, calculated from the digestibility of the rations and crimson clover hay alone, are, while differing considerably, on an average higher than those for corn meal fed alone. The two sets of coefficients presented for albuminoids will be understood by reference to the similar part of the discussion of the trial of corn meal alone. Even then, the real digestibility of the albuminoids of corn meal in the rations appears to be greater than the total protein, which we can only account for on the supposition that some of the amides of the clover hay, which were all digested when the hay was fed alone, escaped digestion in the rations and appeared with the soluble protein from the corn meal in the dung, thus causing too large a coefficient to be used for total protein for crimson clover hay as digested in the rations. This difference occurs in the rations of corn meal and crimson clover hay, and corn-and-cob meal and crimson clover hay, though the difference in the former case is quite small.

TABLE XXVIII.—Showing Percentage Composition of Crimson Clover Hay, Corn Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N ×6.25)	Albumi ids (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay	12.33	87.67	8.20	16.41	13.70	2.40	44.59	28.40
Corn Meal	12.68	87.32	1.51	10.08	10.08	5.03	81.60	1.78
Waste, crimson clover hay, gray goat	16.42	83.58	8.28	17.82	15.50	2.48	44.59	26.83
Waste, crimson clover hay, black goat	12.23	87.77	11.78	17.19	14.87	2.19	44.57	24.27
Solid excrement, gray goat	58 48	41.52	8 49	15 41	13.19	3 46	35.46	37.18
Solid excrement, black goat	59 37	40.63	10.29	17.31	13 87	3.27	33 20	35.93

TABLE XXIX.—Showing Nutrients Consumed and Excreted in Grams with Percentages Digested.

GRAY GOAT. RATION: CRIMSON CLOVER, HAY AND CORN MEAL, 1.83:1.

	Total amount.	DRY MATTER CONTAINS: Dry matter.	Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6 25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay fed	4500.0	3945.2	323.51	647.41	540.49	94.68	1759.16	1120.44
Corn meal fed	1500.0	1309.8	19.78	132.03	132.03	65.88	1068.80	23.31
Total fed	6000.0	5255.0	343.29	779.44	672.52	160.56	2827.96	1143.75
Waste, crimson clover hay	1753.5	1465.6	121.35	261.17	227.16	36.35	653.5	393.22
Total consumed		3789.4	221.94	518.27	445.36	124.21	2174.46	750.53
Total solid excrement	2385.3	990.4	84.09	152.62	130.63	34.27	351.2	368.24
Total digested		2799.0	137.85	365.65	314.73	89.94	1823.26	382.29
Digested from crimson clover hay		1515.3	120.12	263.53	191.57	25.24	735.82	373.79
Digested from corn meal		1283.7	17.73	102.12	123.16	64.70	1087.44	8.50
Per cent. of ration digested		73.60	62.11	70.55	70.66 65.73	72.41	83.84	50.93
Per cent. of corn meal digested		98.00	91.96	77.34	93.28 76.63	98.20	100.00	36.46

BLACK GOAT. RATION: CRIMSON CLOVER HAY AND CORN MEAL, 2.36:1.

Crimson clover hay fed	4500.0	3945.2	323.51	647.41	540.49	94.68	1759.16	1120.44
Corn meal fed	1500.0	1309.8	19.78	132.03	132.03	65.88	1068.80	23.31
Total fed	6000.0	5255.0	343.29	779.44	672.52	160.56	2827.96	1143.75
Waste, crimson clover hay	956.0	839.1	98.85	144.24	124.77	18.38	373.99	203.65
Total consumed		4415.9	244.44	635.20	547.75	142.18	2453.97	940.10
Total solid excrement	3402.0	1382.2	142.23	239.26	191.71	45.2	458.9	496.62
Total digested		3033.7	102.21	395.94	356.04	96.98	1995.07	443.48
Digested from crimson clover hay		1898.1	133.49	343.31	254.17	33.02	921.83	471.23
Digested from corn meal		1135.6	.....	52.63	101.87	63.96	1073.24	.....
Per cent. of ration digested		68.69	41.81	52.33	65.00 56.32	68.21	81.26	47.17
Per cent. of corn meal digested		86.70	.....	39.86	77.15 41.14	97.09	100.00	.....
Mean per cent. of above two rations digested		71.15	51.96	66.44	67.83 61.02	70.31	82.55	49.05
Mean per cent. of corn meal digested in above rations		92.35	45.98	58.60	85.21 58.88	97.65	100.00	18.23

Nutritive ratio of rations of crimson clover hay and corn meal when consumed as 1.83 to 1, 1 to 6.64; when consumed 2.36 to 1, 1:6.77.

In Table XXX, are brought together for comparison the coefficients of digestibility of corn meal when fed alone to goats and pigs, when fed in ration with orchard grass hay to cows, and in rations with crimson clover hay to goats. The corn meal appears to have been better digested in the rations with crimson clover hay than in the ration with orchard grass hay or alone, the increase falling on the fat and carbohydrates, 100.00 per cent. of the nitrogen-free extract being digested in both rations.

TABLE XXX.—Showing the Digestibility of Corn Meal when fed Alone and in Rations by Cows, Goats, and Pigs.

	Dry matter.	Ash.	Protein.	Fats. (Ether extract)	N-free extract.	Crude fiber.
Corn meal fed alone to goat	86.89	0.00	66.89	80.47	94.22	0.00
Corn meal fed in ration of 2.3 pounds orchard-grass hay to 1 pound corn meal (dry matter basis) to cows*	84.6	....	58.3	91.9	87.1	0.00
Corn meal fed in rations of 2.36 and 1.83 pounds crimson clover hay to 1 pound meal to goats	92.35	45.98	58.6	97.65	100.00	18.23
Corn meal fed alone to pigs†	89.5	....	86.1	81.7	94.2	29.4

*N. Y. Experiment Station, 7th Annual Report, pp. 278–9.
†Maine Experiment Station, Report 1885–'6, p. 61.

XVI. DIGESTION OF CORN-AND-COB MEAL,

BY BLACK GOAT.

Date of experiment, April and May, 1893.

Daily ration: 900 grams fed, 800.4 grams eaten.

Total period, 20 days.

Collections, the last 6 days.

Analytical and other data for obtaining the coefficients of digestibility are given in Tables XXXI and XXXII.

The same corn as used in experiments 14 and 15 was ground without shelling and made a rather coarse meal showing small pieces

TABLE XXXI.—Showing Percentage Composition of Corn-and-Cob Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Corn-and-cob meal	12.43	87.57	1.41	9.03	9.03	3.79	76.63	9.14
Waste, corn-and-cob meal	12.46	87.54	1.66	8.93	8.93	4.19	78.57	6.65
Solid excrement	65.08	34.92	7.59	14.79	12.19	2.71	51.66	23.25

TABLE XXXII.—Showing Nutrients Consumed and Excreted in Grams with Percentages Digested.

BLACK GOAT.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N free extract.	Crude fiber.
Corn-and-cob meal fed	5400.0	4728.8	66.68	427.01	427.01	179.22	3673.68	432.21
Waste, corn-and-cob-meal	597.5	523.1	8.68	46.71	46.71	21.91	411.00	34.78
Total consumed	.....	4205.7	58.00	380.30	380.30	157.31	3212.68	397.43
Total solid excrement	2561.2	894.4	67.88	132.28	109.03	24.24	462.05	207.95
Total digested	.....	3311.3	.....	248.02	271.27	133.07	2750.63	189.48
Per cent. of corn-and-cob meal digested	.....	78.73	.....	65.21	*71.33	84.59	85.61	47.67
Consumed in corn of corn-and-cob meal	.....	3417.97	47.14	309.07	309.07	127.85	2599.96	320.99
Consumed in cobs of corn-and-cob meal	.....	787.73	10.86	71.23	71.23	29.46	612.72	74.44
Digested from corn of corn-and-cob meal	.....	2969.87	.....	206.74	237.85	102.88	2449.68	117.76
Digested from cobs of corn-and-cob meal	.....	341.43	.....	41.28	33.42	30.19	300.95	72.10
Per cent. digest'd from cobs	.....	43.34	.....	57.95	46.92	100.	49.12	96.34

Nutritive ratio of corn-and-cob meal, 1:13.19.

*See discussion, p. 125, of real and apparent digestibility of albuminoids in trial with corn meal alone.

of cobs and cracked kernels. After being fed in ration with clover hay, this meal was fed by itself. The goat gained some body weight during this period.

The coarse meal was digested very well. It fell behind the corn meal in every constituent digested except fat.

Corn-and-cob meal has been subjected to digestion once before in this country, the pig being the animal used.*

The coefficients of digestibility obtained in this trial compare very well with those of the Maine Station. As shown below, the Dent corn digested here by the goat, gives a little higher coefficients of digestibility than did the flint corn there as digested by a pig. This is true for all constituents determined except protein.

It is well known that the pig is able to extract more of the protein from its food than do ruminants; for examples, see comparisons with corn meal in Table XXX of this bulletin. The protein was digested well by the goat. Its digestibility was but 10.5 per cent. lower than that for the pig shown in the below comparison, while the per cent. is higher than that of corn meal digested by a cow, and very nearly equal that of corn meal digested by the companion goat in experiment 14. The low percentage of crude

*Maine Agricultural Experiment Station, Annual Reports for 1885-'86.

	Total dry matter.	Organic matter.	Protein (N×6.25)	Albumin'ids (N×6.25)	Fat. (Ether extract)	N free extract.	Crude fiber.
North Carolina Dent corn-and-cob meal	78.73	.....	65.21	71.33	84.59	85.61	47.67
Maine flint corn-and-cob meal	75.6	76.7	75.70	.....	82.0	83.6	28.5

fiber in the waste indicates that the goat may have selected pieces of cobs and eaten this part somewhat better than he ate the corn meal, in which case the coefficients given for cobs would be a trifle higher than that actually digested. It may possibly be also an error of sampling and not a difference of eating.

In calculating the digestibility of the cobs, the coefficients for the corn meal fed alone have been used except that for crude fiber. For that, the coefficient found (36.46) in the experiment on crimson clover hay and corn meal with the gray goat was used. These factors give a very favorable result for feeding corn-and-cob meal.

Shelling a sample 100 pounds of ear corn a yield of 81.5 pounds kernels, and 18.5 pounds of cobs was reached. The analyses show 12.68 per cent. of water in corn meal, and 12.43 per cent. in corn-and-cob meal. From these data there was found 11.35 per cent. of water in cobs, and 71.17 and 16.40 pounds of dry matter, respectively, in these products. The dry matter would be divided between corn and cobs as 71.17 to 16.40.

By feeding the cobs as corn-and-cob meal, 7.11 pounds of digestible dry matter was added to the 61.84 pounds digestible from the kernels. This is equivalent to saving 10.31 per cent. of the digestible food in 100 pounds of ear corn. Or, calculated on shelled corn, and assuming the cobs lost if shelled, it adds 9.84 pounds of digestible food in the cobs to the 75.88 pounds in 100 pounds of corn meal. This is an addition of 12.96 per cent. to the digestible dry matter in the corn meal.

XVII. DIGESTION OF RATION OF CRIMSON CLOVER HAY AND CORN-AND-COB MEAL,

BY BLACK AND GRAY GOATS.

Date of experiments, March and April, 1893.

Daily ration:

- Black goat, { Fed 900 grams hay, 300 grams meal. / Eaten 539.3 grams hay, 300 grams meal.
- Gray goat, { Fed 900 grams hay, 300 grams meal. / Eaten 405.98 grams hay, 300 grams meal.

Total period, 12 days for black, and 14 days for gray goat.

Collection period, the last 5 days for each animal.

Analytical and other data for obtaining the coefficients of digestibility are contained in Tables XXXIII and XXXIV.

The hay was fed in much larger amounts than eaten by the goats and was eaten by them in different proportions. This gives two quite distinct rations which have affected the percentages digested in a somewhat marked degree and as would be expected, though not at first glance appearing to harmonize with the results of other

TABLE XXXIII.—Showing Percentage Composition of Crimson Clover Hay, Corn-and-cob Meal, Waste, and Solid Excrement.

	Water.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6 25)	Albumi'ds (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract	Crude fiber.
Crimson clover hay	12.33	87.67	8.20	16.41	13.70	2.40	44.59	28.40
Corn-and-cob meal	12.43	87.57	1.41	9.03	9.03	3.79	76.63	9.14
Waste, crimson clover hay, black goat	16 86	83.14	8.84	16.85	13.12	2.34	43.51	28.46
Waste, crimson clover hay, gray goat	11.81	88.19	8.66	19.93	16.37	2.87	46.39	22.15
Solid excrement, black goat	58.55	41.45	8.98	14.47	12.00	3.21	38.02	35.32
Solid excrement, gray goat	58.24	41.76	8.55	14.79	12.12	2.97	37.81	35.88

experiments on rations with variations in the same direction. The corn-and-cob meal, while containing a comparatively large amount of carbohydrates, is in itself a very easily digestible article, partly from its low content of crude fiber. The hay, on the contrary, while a good sample of hay, yet contains in relation to the meal much the larger proportion of crude fiber. This gives a variation quite different from that where the excess of carbohydrates in the wide ratio rations have contained large amounts of crude fiber. The digestibility of the protein in the wide ratio ration is still depressed a little below that of the narrower ration, while the high digestibility of the constituents of the meal united with the relatively large amount in the wide ratio ration eaten, yield slightly higher coefficients than are found in the narrower ration for all other constituents.

These rations were well digested, but fall behind the exceedingly easily digestible ration of corn meal and clover hay by from 6 to 10 per cent. of the different constituents. There were no very wide differences while there was a high degree of regularity in the excess of each of the coefficients except protein of the wide ratio ration over those of the narrow one. The constituents of the corn-and-cob meal except the protein, were digested about as well in the ration as when fed alone.

TABLE XXXIV.—Showing Nutrients Consumed and Excreted in Grams with Percentages Digested.

BLACK GOAT. RATION: CRIMSON CLOVER HAY AND CORN-AND-COB MEAL, 1.8:1.

	Total amount.	Dry matter.	DRY MATTER CONTAINS					
			Ash.	Protein (N×6.25)	Albumin'ids (Alb. N ×6.25)	Fats. (Ether extract)	N-free extract.	Crude fiber.
Crimson clover hay fed	4500.0	3945.2	323.51	647.41	540.49	94.68	1759.16	1120.44
Corn-and-cob meal fed	1500.0	1313.6	18.52	118.62	118.62	49.78	1006.61	120.06
Total fed	6000.0	5258.8	341.03	766.03	659.11	144.46	2765.77	1240.50
Waste, crimson clover hay	1803.3	1499.3	132.54	252.63	196.71	35.08	652.34	426.70
Total consumed	.....	3759.5	209.49	513.40	462.40	109.38	2113.43	813.80
Total solid excrement	3110.3	1289.1	115.80	186.50	154.69	41.38	490.12	455.31
Total digested	.....	2470.4	93.69	326.90	307.71	68.00	1623.31	358.49
Digested from crimson clover hay	.....	1494.7	113.47	269.36	210.19	25.79	736.59	356.58
Digested from corn-and-cob meal	....	975.7	.....	57.54	97.52	42.21	886.72	1.91
Per cent. of ration digested	.....	65.71	44.72	63.67	66.54 59.67	62.17	76.81	44.05
Per cent. of corn-and-cob meal digested	.....	74.28	.....	48.51	82.21 55.40	84.79	88.09	1.59

GRAY GOAT. RATION: CRIMSON CLOVER HAY AND CORN-AND-COB MEAL, 1.35:1.

Crimson clover hay fed	4500.0	3945.2	323.51	647.41	540.49	94.68	1759.16	1120.44
Corn-and-cob meal fed	1500.0	1313.6	18.52	118.62	118.62	49.78	1006.61	120.06
Total fed	6000.0	5258.8	342.03	766.03	659.11	144.46	2765.77	1240.50
Waste, crims'n clover hay	2470.1	2178.4	188.64	434.16	356.60	62.52	1010.56	482.51
Total consumed	.....	3080.4	153.39	331.87	302.51	81.94	1755.21	757.99
Total solid excrement	2185.2	912.5	78.02	134.96	110.60	27.10	345.02	327.41
Total digested	.....	2167.9	75.37	196.91	191.91	54.84	1410.19	430.58
Digested from crimson clover hay	.....	1079.7	80.14	145.50	112.43	13.92	498.19	327.90
Digested from corn-and-cob meal	.....	1088.2	.....	51.41	79.48	40.92	912.00	102.68
Per cent. of ration digest'd	.....	70.37	49.13	59.33	63.44 55.39	66.92	80.34	56.81
Per cent. of corn-and-cob meal digested	.....	82.84	.....	43.34	67.00 *46.48	82.20	90.60	85.52
Mean per cent. of above two rations digested	.....	68.04	46.93	61.50	64.99 57.53	64.55	78.58	50.43
Mean per cent. of corn-and-cob meal digested in above rations	.....	78.56	.....	45.93	74.60 *50.94	83.50	89.35	43.55

Nutritive ratio of ration of 1 pound corn-and-cob meal to 1.8 pounds crimson clover hay, 1:6.58.

Nutritive ratio of ration of 1 pound corn-and cob meal to 1.35 pounds crimson clover hay, 1 to 10.04.

*See discussion (p. 126) of real and apparent digestibility of albuminoids in rations of corn meal and crimson clover hay.